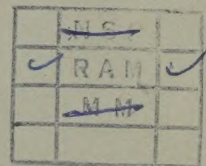


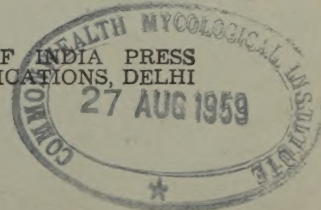


SCIENTIFIC REPORTS
OF THE
INDIAN AGRICULTURAL RESEARCH INSTITUTE
FOR THE YEAR ENDING
30TH JUNE, 1955



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Part I

REPORT OF THE DIRECTOR

I. (a) INTRODUCTORY

On the 1st April, 1955, the Institute completed fifty years of service to Indian agriculture and celebrated its Golden Jubilee in a befitting manner. The celebrations were inaugurated by Dr. S. Radhakrishnan, Vice-President of India, in the presence of a large and distinguished gathering. On the 2nd of April, Shri Jawaharlal Nehru, Prime Minister of India, presided over a Special Convocation and gave away the Diplomas of Associateship of the Institute to the post-graduate students who successfully completed recently their two-year post-graduate training at the Institute, and awards to those students who stood first, in their respective subjects of training, at the previous Preliminary Diploma Examination.

On the 3rd of April, Dr. P. S. Deshmukh, Union Minister of Agriculture, inaugurated a Farmers' Day in which about 500 farmers from all over the country participated. The visiting farmers and other guests were shown round, and they were greatly interested in the exhibition, organised in each Division of the Institute, illustrating the numerous achievements, fundamental as well as those of practical significance, stemming from the Institute's researches in the several branches of the agricultural sciences.

A dinner party was given on the 3rd of April at which Shri K. M. Munshi, Governor, Uttar Pradesh and Mrs. K. M. Munshi were the chief guests.

An important feature of the Jubilee celebrations was a series of talks and a symposium in which distinguished scientists, administrators and past students of the Institute took part. Shri Humayun Kabir, Secretary to the Government of India, Ministry of Education, delivered an address on "Our Heritage" under the Chairmanship of the late Shri G. V. Mavalankar, Speaker, Lok Sabha. Shri V. T. Krishnamachari, Vice-Chairman, Planning Commission, presided over the talk on "Radio-carbon Dating" given by Dr. K. S. Krishnan, F.R.S. Director, National Physical Laboratory, New Delhi. The third address was by Shri V. P. Goswami, Secretary, Community Projects Administration, who spoke on "Community Projects"; Shri P. N. Thapar, Secretary to the Government of India, Ministry of Food and Agriculture, was Chairman. Shri R. S. Krishnaswamy, Vice President, Indian Council of Agricultural Research, presided over a symposium, which lasted for four days, on agricultural research in India during the past fifty years. A number of distinguished speakers, including Directors of Agriculture of some States and other noted agricultural scientists, took part in the symposium. Among the former post-graduate students of the Institute, who delivered talks, were Dr. T. R. Mehta—"The Practical Approach to Plant Breeding"; Dr. A. D. Khan—"The Pattern of Soil erosion in Uttar Pradesh"; Dr. N. Prasad—"Variability and taxonomy of fungi"; Dr. S. Krishnaswamy—"Lac Cultivation and Entomological Aspects of Lac Research"; Dr. W. V. B. Sundara Rao—"Some Recent Trends in Soil Microbiology". Appendix IV gives detailed information regarding the talks and the evening addresses delivered during the Golden Jubilee Celebrations.

The concluding function of the celebrations was held in the afternoon of the 4th of April; Shri M. V. Krishnappa, Deputy Minister for Food, Government of India, was the chief guest. In the evening, a reception was given by the Minister of Food and Agriculture in the Rashtrapati Bhawan gardens.

An illustrated handbook, briefly depicting the activities of the Institute, and a Golden Jubilee Souvenir were published on the eve of the Jubilee celebrations. Messages of goodwill, which were incorporated into the souvenir volume, were received from a large number of distinguished persons, as well as heads of scientific institutions, at home and abroad. Besides, the souvenir included a number of authoritative articles, reviewing the progress made in different fields of agricultural science in India.

Three talks were broadcast, during the celebrations, over All India Radio, namely, one by Dr. P. S. Deshmukh, Union Minister for Agriculture, another by Dr. B. P. Pal, Director of the Institute, and the third talk by Shri Bharat Singh, farmer from one of the villages in Delhi State in which the Institute operates a Scheme for carrying the fruits of its researches to the farmers' fields; he gave an interesting account of what the Institute meant to the farming community at large.

Over a score of popular scientific articles, depicting the contributions made by the Institute to the Nation's Agriculture, were published in many languages in the country's newspapers and magazines.

(b) LEAVE, TRANSFER, AND POSTINGS OF GAZETTED STAFF

Directorate

Dr. B. P. Pal, Director, was away from 26th June, 1954 to 25th July, 1954 on deputation as Leader of the Indian delegation to the 8th International Congress of Botany held in Paris. Dr. T. J. Mirchandani, Head of the Division of Agronomy, held charge of the current duties of the post of Director during this period.

Division of Agronomy

Consequent on the appointment of Dr. J. N. Sharma to the post of Agronomist with effect from 18th February, 1955, Shri J. J. Chandnani and Shri K. P. Misra reverted to their posts of Assistant Agronomist and Research Assistant respectively. Shri C. Vedantiah was appointed on 14th June, 1955 as Technical Officer in the Tractor Testing Scheme.

Division of Botany

Dr. M. S. Swaminathan was appointed to the post of Assistant Cytogeneticist with effect from 4th October, 1954; Shri V. S. Mani was appointed as Assistant Plant Physiologist under the Citrus Die-back Disease Scheme with effect from 18th August, 1954 and Shri S. P. Mittal was appointed to the post of Assistant Botanist under the Plant Introduction Scheme with effect from 11th April, 1955. Shri S. Sen, Assistant Wheat Breeder, was relieved on 20th June, 1955 to enable him to take up an appointment in West Bengal.

Division of Soil Science and Agricultural Chemistry

To enable him to join his new post as Development Officer in the Ministry of Commerce and Industry, Dr. K. C. Gulati was relieved of his post of Organic Chemist with effect from 14th July, 1954. On return from the U.S.A. after completion of his training, Shri L. M. Mathur was appointed to the post of Cartographer under the Technical Co-operation Mission Scheme with effect from 21st September, 1954. Dr. R. S. Murty was appointed to the post of Assistant Soil Survey Officer with effect from 13th August, 1954 and Dr. B. M. Lal to the post of Assistant Biochemist with effect from 1st October, 1954. Dr. B. Ramamoorthy, Assistant Physical Chemist, rejoined his duty on 15th December, 1954 after completion of nine months of training in the United Kingdom in Spectro-chemistry and Radio-active tracer technique under the Colombo Plan.

Division of Entomology

Dr. E. S. Narayanan, Head of the Division of Entomology attended the Sixth Commonwealth Entomological Conference held in London as Government representative from 7th July to 16th July, 1954. Again on 16th April, 1955, he left for the United States of America, under the 'Point-Four' Training Programme, to study the methods of biological control of pests of agricultural crops. During his absence abroad from 16th April, 1955 to 6th, September, 1955 Dr. S. Pradhan, Insect Ecologist, held charge of the Division. Shri H. N. Batra was appointed to the post of Assistant Insect Epidemiologist. Shri C. K. Samuel, Assistant Systematic Entomologist, retired from service on 5th April, 1955. After completion of his training for one year at Cambridge under the Colombo Plan, Dr. Rattan Lal, Assistant Insect Physiologist, resumed duties on 18th October, 1954.

The Institute suffered a great loss by the untimely passing away of Dr. S. Mukherji, Systematic Entomologist, on 31st October, 1954 after a brief illness.

Dr. E. S. Narayanan, Head of the Division of Entomology, was on earned leave from 1st to 26th December, 1954, when Dr. S. Pradhan, Insect Ecologist, held charge of the Division.

Division of Mycology and Plant Pathology

Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, was on deputation abroad from 26th June, 1954 to 10th August, 1954 attending the meetings of the International Commission on Plant Diseases Losses, of which he is a member, and of the Plant Pathological Section of the 8th International Botanical Congress held at Paris. While out of India he also attended the 5th Commonwealth Mycological Conference in London as Leader of the Indian delegation. He visited important mycological and plant pathological centres of research in the United Kingdom to see the latest developments in the subject. Dr. M. L. Gattani, Assistant Plant Pathologist, resumed his duties on 11th August, 1954 on the expiry of 1½ months' earned leave. The services of Dr. Vasudeva were placed at the disposal of the Food and Agricultural Organization of the United Nations from 2nd May, 1955 and Dr. B. L. Chona, Systematic Mycologist was appointed to officiate as Head of the Division of Mycology. Dr. S. P. Raychaudhuri, Assistant Virologist, and Shri D. N. Srivastava, Research Assistant, were appointed to officiate as Systematic Mycologist and Assistant Virologist respectively.

(c) ACCOUNTS DURING 1954-55

The total expenditure, excluding that on schemes financed by the Indian Council of Agricultural Research and the Cominodity Committees, of the Institute and its Sub-stations at Karnal and Pusa during the financial year ending 31st March, 1955 amounts to Rs. 26,48,915 as under :—

	Rs.
I. (i) General expenditure at the Institute including the office of the Director, Irrigation, Power Supply, Gas Plant, Estate Establishment, IARI Dispensary, etc.	5,43,882
(ii) Division of Statistics	24,778
(iii) Division of Chemistry	3,08,097
(iv) Division of Mycology	2,06,500
(v) Division of Entomology	1,86,058
(vi) Division of Botany	4,04,943
(vii) Division of Agronomy	3,44,122
(viii) Division of Agricultural Engineering	1,65,983
(ix) Division of Economics	7,406
(x) Central College of Agriculture	2,85,073
TOTAL	24,76,842
II. <i>Experimental Farms :</i>	
(i) Agricultural Research Sub-station, Karnal	1,05,300
(ii) Botanical Sub-station, Pusa	66,773
TOTAL	1,72,073
GRAND TOTAL OF I AND II	26,48,915

2. SUMMARY OF MAIN RESULTS OF RESEARCH

AGRONOMY

A. General :

The agronomic experiments in the "Determination of Soil Fertility and Fertiliser Use" project, referred to in the previous report, were conducted at all the 40 centres in India.

B. Soil fertility experiments :

Investigations on manuring in rotation, a good soil management practice, remained in progress. These indicated that wheat responded to green manuring with *guar* (*Cyamopsis tetragonoloba*), but the residual effect on maize and wheat crops was not appreciable in the third cycle of the rotation: *sannhemp—wheat—maize—wheat*. The top dressing of green manure (*guar*) with phosphate, boron and molybdenum enhanced the outturn of wheat more than green manure alone. Experiments for maintaining soil fertility under exhaustive and restorative rotations with adequate manuring the exhaustive rotation of *wheat—maize—wheat—maize* with 60 lb. N as organic and inorganic manures, the yields obtained were not as high as under the restorative rotation of *maize—wheat—maize—peas* rotation at the same levels of fertilization. Similarly, in the second cycle, high yields of *bajra* (pearl millet and wheat in the same year, in spite of highest rate of manuring, were not obtained. Phosphate fertilization of berseem enriched the soil as evidenced by high outturn of subsequent crops of *maize—berseem—cotton* in the rotation. In *paddy—wheat* rotation both crops required fertilization with 30-60 lb. N per acre.

C. Manurial experiments:

(i) *Green manuring*.—For the third successive year, ploughing under the green manure after eight weeks gave the highest yield. Green manuring together with a dressing of ammonium sulphate at 60 lb. N per acre produced significantly higher yield than green manuring alone. Once again green manuring with *dhaincha* resulted in significantly higher yield of paddy than cultivated fallow. On paddy, dressing of ammonium sulphate at 20 and 40 lb levels of N in conjunction with green manure showed little extra response.

(ii) *Nitrogenous manures and fertilizers*.—Experiments on the relative efficiency of ammonium sulphate, chilean nitrate, ammonium nitrate and urea were conducted on wheat, paddy, sugarcane and cotton. On cotton, chilean nitrate proved superior to ammonium sulphate. Ammonium sulphate indicated higher relative efficiency than urea or ammonium nitrate on paddy. With wheat and sugarcane, various nitrogenous source materials showed similar response. For the second season wheat responded much less to farmyard manure than ammonium sulphate alone or a combination of F.Y.M. and ammonium sulphate when applied at 60 lb N level per acre. Analysis of combined three years' data indicated a linear response to chemical fertilizer nitrogen for rates ranging from 20 to 100 lb. N as indicated by the wheat crop. With the tobacco crop for the second year, 40 and 80 lb. N per acre as ammonium sulphate showed significant response over control.

Two applications of ammonium sulphate at 15 lb. N level each, once at transplanting of paddy and the next at tillering, produced higher yield than single application. Similar results of the superiority of fractional application of nitrogen over single dressing at sowing were indicated by the wheat crop.

(iii) *Phosphate fertilization*.—Among the different sources of phosphorus, namely, superphosphate, bone meal, rock phosphate and Trichy nodules, only superphosphate significantly increased the yield of berseem fodder.

Manuring of paddy nursery with 1,000 and 2,000 md. of F.Y.M. per acre had small effect on transplanted crop which confirmed previous results.

(iv) *Fertilizer use project experiments*.—Experiments conducted on paddy and wheat in cultivators' fields in 22 out of 55 Community Projects in India, were 850 and 835 respectively under Indo-American Technical Co-operation Agreement on 'Soil Fertility and Fertilizer use'. At 20 lb level of nitrogenous fertilization relative efficiency of urea and ammonium sulphate with paddy and wheat was the same, the relative responses being 3.19 md. of paddy and 2.30 md. of wheat per acre. At 40 lb level of N, ammonium sulphate gave higher yield by 0.46 md. over urea with paddy, but equal grain outturn with wheat.

The fertilizing values of superphosphate and bone meal were compared on acid soils on paddy crop. At 20 lb. P_2O_5 level the response was the same. The fertilizers compared on wheat crop were superphosphate, nitrophos and ammophos. Ammophos proved superior to superphosphate. The mean responses to 20 lb. P_2O_5 in superphosphate were 1.43 md. for paddy and 1.90 md. for wheat.

The complex experiment conducted on 15-acre blocks on paddy and wheat almost have shown identical results as in the cultivator field trials.

D. Cultural experiments :

In general, deep ploughing with a tractor plough or a soil-inversion bullock plough, did not show any advantage in yields of maize, cotton, wheat, pigeon pea, sugarcane, potato and carrots, over shallow ploughing with bullock drawn country plough which confirmed previous results of two years on alluvial soils. The interaction between rates of fertilization with nitrogen and depths of cultivation did not prove significant. The responses to fertilization were independent of cultivation treatments. With maize, frequency of ploughing did not indicate significant effect, but three hoeings gave significantly higher yields of maize over the control treatment.

Plough-sole placement of fertilizer for maize proved significantly superior to broadcasting or placing in lap of the furrow. But it made no difference for the pigeon pea crop. For the third successive year broadcasting, drilling and transplanting of paddy indicated small differences in crop yields.

E. Weed control experiments :

Baru (*Sorghum halepense*) is a pernicious perennial weed in the cultivated area. T.C.A. and C.M.U. were tried for its eradication. The latter was found more effective than the former. The mortality with C.M.U. treatment was found to be 70-80 per cent.

F. Irrigation experiments :

Once again for berseem, fourteen irrigations, each 3 inches deep, gave significantly better results than 10 irrigations. As in the last year, for wheat, 2-3 irrigations gave significantly higher yield than one irrigation. Investigations on sugarcane indicated significant differences in the irrigation intervals of 10, 15 and 20 days, unlike last year. The interaction between rates of nitrogen and irrigation intervals was not observed.

G. Varietal trials :

The varieties of crops with superior performance compared to local standards were : wheat, N.P. 792, N.P. 718, N.P. 710 and N.P. 797; hybrid maize, Texas 26 and North Carolina 27; *bajra* Pb. T/55 and B. 207; tobacco, N.P. 219; sugarcane, Co. 647, Co. 797 and B.O. 11; paddy, N.P. 130 and N.P. 137 for medium and late seasons; and *jowar* types, J.C. 20 and J.C. 21 for fodder.

H. Seed distribution:

There was growing heavy demand for New Pusa wheats from Rajasthan, Madhya Bharat, Uttar Pradesh and Bhopal and in particular, for N.P. 710 and N.P. 718. The total quantity of seeds of wheat, paddy, oats, maize, peas, berseem and other crops was 2,233 md. In addition to this 1,145 seed samples of grasses of legumes and 240 dozen crowns of kudzu vine were distributed all over India.

I. Intensive cultivation scheme:

As usual the demonstrations arranged in Intensive Cultivation Scheme area were 696 or about 37 demonstrations per village. Area sown with New Pusa rust resistant wheat varieties was 1,095 acres, major portion of which is monopolised by N.P. 718, an early maturing, low water demanding variety which yielded $2\frac{1}{2}$ md. extra outturn over local. About 2,900 md. of nucleus seed was supplied to Rajasthan and Madhya Bharat Departments of Agriculture. Other varieties recommended were barley—N.P. 13; oats—N.P. 1; gram—N.P. 58; tobacco—N.P. 219 and 220; peas—N.P. 29; sugarcane—Co. 647; *bajra*—Pb. T/55; sweet potato—FA-17, etc. Besides, demonstrations on green manuring and fertilizers, control of pests and diseases and improved implements were arranged. Locust control was a special feature of work this year. Villagers took part in the I.A.R.I. Golden Jubilee celebrations.

J. Agronomic experiments in relation to wheat rusts :

Experiments were conducted both at New Delhi and Pusa. At New Delhi, the intensity of rust was greater in plots treated with high doses of nitrogen exceeding 40 lb. N per acre. Rust incidence still further increased with three irrigations and 40 lb. N per acre. At Pusa, intensity of black rust was found to be light to medium under one or two irrigation treatments.

K. Agrostology :

Among grasses, *Setaria sphacelata*, *Brachiaria mutica*, *B. brizantha*, *Pennisetum pedicellatum* and *P. polystachyum* showed good performance. Of the legumes, *Desmodium purpureum*, *D. scorpiurius*, *D. tortusum*, *D. uncinatum*, *Phaseolus lathyroides*, *Lupinus termis* and *Mucuna cochinchinensis* indicated promise.

From the trials conducted during last three years, it was found that good yield of maize can be obtained after a crop of wheat and Hubam clover mixture.

Experiments to determine the flat carrying capacity of *anjan* (*Cenchrus ciliaris*) and *apang* (*Dichanthium annulatum*) pasture grasses was found to be 0.67 and 0.52 adult animal per acre.

L. Cattle breeding and management:

There was further improvement in the wet and over-all milk yield averages of the Sahiwal herd over last year; the figures were 23·2 and 15·9 lb. respectively. Out of nineteen cows completing lactations, three did over 9,000 lb. and two over 8,000 lb. per lactation of 306 days.

There was slight fall in average birth weight of male calves from 61·2 to 59·5 lb., but of the female calves was well maintained at 56·7 lb. The growth rates of male and female calves were 1·1 and 1·2 lb. per head respectively per day, slightly less than preceding year.

The early maturity heifers gave on the average 6,181 lb. milk yield as against 6,221 lb. for the adult cows. The average age at first calving was 2 years 7 months and 22 days.

Under the Key Village Scheme, a survey was conducted of the general agricultural conditions cattle population and fodder requirements in the 19 villages in Delhi.

AGRICULTURAL ENGINEERING

A. Test Of Tractors

Trial of Tractors: Trials were conducted of a garden type 'Chief Tractor' & also of the Russian Model XT 3-7 Tractor. Details will be found in the report of the Division of Agricultural Engineering.

B. Experiments on rice cultivating and Processing Implements and Machines

Trial of hand operated Japanese paddy huller: Experiments were conducted on paddy huller imported from Japan for its output, percentage of broken rice and unhulled paddy. At 3000 revolutions per minute—the speed at which the machine gives its best performance—the output of the huller was 13 to 14 maunds of paddy per day of 8 hours. It left about 15·4% of paddy as unshelled. The machine requires three men, two for its operation, and one for feeding the paddy to the hopper. The machine is rather heavy for continuous operation by two men.

C. Experiments on Water Lifts Etc.

Trial of Charsa: During the previous year experiments were conducted on a *charsa*, the indigenous water lift with a leather bucket, which is in use in Northern parts of India and two *charsas* had been tried in villages for their draft, output and efficiency. These *charsas* required two men for their operation and control. During the current year, an improvement on the indigenous *charsa* was effected by providing a self-delivery leather tube similar to that used in South India, which is intended to save the labour of one man. The improved *charsa* requires only one man for its operation and control. The improvement has also resulted in increasing the efficiency from 48·2% to 60·2% of the *charsa* which is under further trial.

D. Trial of Hand Push Carts and Wheel Barrows:

At the instance of Dr. P. S. Deshmukh, Union Minister for Agriculture, experiments were conducted to find a cheap and efficient hand push cart and wheel barrow for use by farmers. It was found that a cheap light cart made of mild-steel sheets and cast iron wheels was suitable for farm use. It costs Rs. 90 and has a capacity of 13 cubic feet. It was also found that there was very little effect of changing over to rubber tyred wheels and there was no difference between ordinary brass or ball bearings. In the wheel-barrows, one with a single wheel of $2\frac{1}{2}$ cubic feet capacity, with solid rubber wheels costing Rs. 65 was found to be satisfactory.

E. Scythes

Trials on scythes imported from Western countries were conducted in order to compare their performance with the Indian implement used for harvesting. It was found that it was difficult for an average farm-worker to work continuously with the scythe. Besides, it was found that it could be used only for green fodder and not for harvesting grain crops.

BOTANY

A. Plant Breeding and Genetics :

(i) *Breeding rust and smut resistant wheat varieties* : This work was continued at Delhi and at the Sub-stations at Pusa, Simla, Indore and Wellington. The object is to evolve high yielding wheat varieties resistant to all the three kinds of rust in India and to smuts. For this, an elaborate breeding programme, involving crosses, double crosses and back-crosses between commercial wheats and disease resistant, indigenous and foreign wheat varieties, is under way at these centres for introducing into improved strains disease-resistance from diverse parental sources. At Delhi alone, progenies obtained from about 75 crosses were tested in the field, besides several Indian and exotic wheat varieties, for resistance to rust under artificially-created conditions of rust epidemics; observations were recorded on over 15,000 individual plants from which about 1,700 promising ones were selected for further testing. In the studies under way on the mode of inheritance of rust resistance, resistance in the seedling stage to Race 15 C was found to be controlled by a single dominant gene while duplicate genes governed resistance to the races, 21 and 42.

E. 871, a wheat strain received from the U.S.A., was found to be highly resistant in the seedling stage to 12 out of the 13 Indian races of black rust, to all the 8 races of brown rust, and to 3 out of 8 races of yellow rust. To the thirteenth race of black rust (No. 122), to which most of the varieties in the collection were susceptible, this strain showed semi-resistant reaction.

The loose smut tests confirmed the high resistance of all the leading N.P. wheats.

Preliminary work done on the reaction of wheat varieties to the European bunt, prevalent in the northern hills, showed that N.P. 785 and N.P. 786 were highly resistant.

Work has also been taken up on the breeding of varieties resistant to drought and lodging.

Yield tests conducted at several centres in the wheat growing tracts of India have further confirmed the general superiority, in the plains, of N.P. 710 and N.P. 718 in respect of yield, rust tolerance and grain quality, observed in the previous years. There was a tremendous demand, totalling over 8,000 mds. for the nucleus seed of these improved wheats. Of this, only about 2,000 mds. could be supplied from out of the Institute's production; about 1,200 mds. were made available from the produce of these varieties obtained from Delhi villages and 500 mds. of N.P. 710 were produced by the Gwalior Dairies in Madhya Bharat. The U.P. Department of Agriculture was reported to have produced and distributed about 5,000 mds. of seed of N.P. 710.

Yield trials at a number of centres in the plains have brought out the outstanding superiority, in respect of yield and rust resistance, of two of the newer N.P. wheats, *viz.*, N.P. 797 and N.P. 799. Both these wheats have shown resistance to 10 races of black rust and 4 races of brown rust.

In the northern hills, N.P. 770 has spread over a considerable area in the higher hills; N.P. 809 is also becoming popular.

(ii) *Rust and wilt resistant linseeds*: Progress was made in the breeding of early-maturing, rust and wilt resistant strains. Some of the recently-evolved strains, *viz.*, N.P. (R.R.) 439 and 440, have done exceedingly well at Delhi, Karnal Kanpur and Patna. At Gwalior, all the N.P. (R.R.) strains under trial significantly outyielded the local check varieties; besides, the former were completely free from rust whereas the latter showed 100 per cent infection. A number of new rust resistant selections, earlier in maturity and superior in yield, have been obtained from progenies of crosses.

(iii) *Wilt resistant pigeon pea (arhar)*: Results of trials again confirmed the superiority of the wilt resistant strains; N.P.C. 15 Pusa, N.P.C. 15 W.E. and N.P.C. 38. Three more hybrid derivatives—*viz.*, P. 14, P. 48 and P. 226, appear promising as early maturing wilt-resistant strains. They will be further tested.

(iv) *Chilli*: Among pungent chillies, N.P. 46A and N.P. HYB. 5-1-5 were again the most superior ones. The seed of N.P. 46A was in great demand from growers. A fresh collection of indigenous and foreign chilli varieties, and of some related species, was made with a view to undertaking work on breeding for disease resistance in this crop.

(v) *Tomato*: The two varieties—"Sioux" from America and the indigenous selection "Improved Meeruti", again stood out the best among a collection comprising over 200 varieties. Improved Meeruti was observed to be remarkably free from virus infection in the autumn—winter crop which, normally, is considerably damaged by viruses. The F_1 hybrid, (Improved Meeruti X Sioux), gave about 67% increased yields over the superior variety. Experiments were under way to use male-sterile lines which would facilitate commercial production of hybrid tomato seed.

(vi) *Bhindi*: Further selections, which are early-maturing and possess good economic characters and are also relatively free from symptoms of the mosaic disease, were made in progenies of crosses between "Pusa Makhmali" and some mosaic tolerant varieties. The seed of "Pusa Makhmali" was in great demand from growers. The F_1 hybrid of the cross between this variety and another variety, I.C. 1510, gave about 60% increased fruit yields.

(vii) *Brinjal*: Two improved varieties, *viz.*, "Pusa Purple Long" and "Pusa Purple Round", have been finally selected and their seeds were multiplied for distribution.

(viii) *Other vegetables*: Having completed the assessment of varietal collections of various vegetables, information regarding twenty promising varieties of cauliflower, peas, bottle-gourd, cowpea, *guar*, *bhindi*, *luffa* gourds, brinjal, and tomato, and on their cultivation, was published as a series of articles in "Indian Farming". This led to a heavy demand from growers for seeds of these vegetables, of which about 280 lbs. were supplied.

(ix) *Jowar and Bajra*: The bajra varieties, Baroda No. 207 and the Punjab Type 55, were again found to be the best for Delhi conditions. Inbreeding was commenced in these types. In *jowar*, the Punjab varieties—No. 263 and No. 893, appeared to be good fodder types. The former type was crossed with Sweet Sudan Grass and Tift Sudan Grass for producing drought-resistant fodder *Jowars*.

(x) *Maize*: Additions were made to the collection of varieties which now comprises 72 indigenous and 94 foreign varieties. Among the latter, two varieties—Jellicose and Amarillo de Cuba, gave very good performance. Inbreeding was commenced in them. In a study of several hundred inbred lines, there were indications that crosses between indigenous and some foreign inbred lines would give marked hybrid vigour. It was also found possible to test inbreds, for their general combining ability, in the first or second inbred generation, it being not necessary to do further inbreeding. Yield trials with foreign hybrid maize at many centres in India again showed that the hybrids, N.C. 27 and Texas 26, were among the topmost performers; the former hybrid gave at Delhi $56\frac{1}{2}$ mds. of grain per acre as compared to 46 mds. given by Kanpur Type 41.

(xi) *Forage grasses and legumes*: A collection comprising 132 strains of indigenous and exotic grasses and 40 strains of legumes was under study. Two strains of *Pennisetum ciliare* (I.C. 2,136 and E.C. 5,603), one of lucerne (I. C. 3,143) and one (I. C. 2,131) of *apang* grass (*Dichanthium annulatum*) appeared promising as forage types. The grass species *Urochloa mosambicensis* and *Brachiaria brizantha*, remained green throughout the year at Delhi under entirely rainfed conditions.

B. Cytology and Cytogenetics :

(i) *Autopolyploidy*: In yield tests conducted at Delhi and Pusa, the *elite* populations of tetraploid *toria* gave higher yields than the commonly grown diploid type. Tetraploids were obtained, by means of colchicine treatment, in the fodder legumes, *berseem* and *senji*.

(ii) *Triticum*: Work was commenced on the utilisation of monosomic lines in bread wheat for locating, on particular chromosomes, genes for resistance to the several physiologic races of the three wheat rusts.

(iii) *Solanums*: Segmental interchange appeared to play a role in the differentiation of the non-tuber-bearing species, *Solanum torvum* and *S. hispidum*.

(iv) *Bhindi*: The second generation of the amphiploid, obtained by crossing cultivated *bhindi* (*Abelmoschus esculentus*, $2n=130$) with the wild species, *A. tuberculatus* ($2n=58$), was grown; the plants showing fields resistance to yellow-vein-mosaic were backcrossed to cultivated *bhindi* for evolving disease-resistant strains of the latter.

(v) *Cytological technique*: An improved smear technique, involving the use of propiono-carmin as stain-fixative, was developed for the study of microsporogenesis in plants with small chromosomes.

(vi) *Grasses* : The existence of polyploid series was observed in natural populations of the common grasses, *Chrysopogon montanus*, *Heteropogon contortus*, and *Dichanthium annulatum*.

C. Crop Physiology :

(i) *Study of drought resistance in wheat*.—There were indications of varietal differences in the yellowing of foliage during the period of grain-setting. A variety with a slowly—yellowing foliage, under soil drought, appeared to yield better than one with more rapidly—yellowing foliage. Under adequate water supply, however, no such distinction was noticeable.

(ii) *Plan Hormones*.—Under pot-culture, spraying with alpha-naphthalene acetic acid (NAA) increased the yield of the wheat variety, Pb. C. 228, but not of N.P. 710. The latter variety did not also respond to this hormone under field conditions. In the past, N.P. 710 has been found to inconsistently respond to NAA. The effect of soaking wheat seeds in 2, 4-D, prior to sowing, on the yield of wheat, was again found to be negligible.

The weed, *Kans* (*Saccharum spontaneum*), was effectively checked by the application of CMU to the soil at the rate of 40 lbs. to the acre, there being little regrowth a year after the treatment.

(iii) *Micro-nutrients*.—Application of 2 lbs. of boron per acre to the soil increased the yield of wheat, over the NPK control, by 3.7 mds.

A study of the grape-fruit, malta and mandarine trees in the Institute orchard, which were showing symptoms of chlorosis and die-back, indicated that deficiencies of iron and zinc were involved.

(iv) *Comparative studies on diploid and autoteraploid toria* (*Brassica campestris* var. *toria*).—A study of fruiting and seed setting led to the important finding that the yield of the autotetraploids could be further increased by selecting on the basis of seed-setting on secondary branches.

D. Systematic Botany and Plant Introduction :

Plant Introduction.—1,475 samples of seeds of crop plants and other economic plants were introduced from abroad. The items collected from within the country numbered 969. The total collection now comprises 11,971 items.

Further progress was made in the evaluation and utilisation of some of the newer introductions. Among these, mention may be made of : a “closed-anther” mutant, useful for breeding work, in the American tomato variety, “John Baer”; two Dutch tomato varieties, “Renova” and “Waltham Mold Proof Tarching” and the American, “Ace”; the American variety of onion, “Red Creole”, possessing good storage quality, and two Japanese onions—“T.1” and “T.4”; a non-shattering East African variety of soybean—N.49; and an American 70-day cowpea variety “Cream No. 40”, producing attractively—bold white grains.

Herbarium.—100 specimens, which include some grasses and other plants collected from the *terai* region of Uttar Pradesh, were added during the year. The number of specimens in the herbarium now totals 5,500.

E. Horticulture :

The 30-acre garden area was systematically laid out. So far, a total of 16 acres have been planted to several varieties of fruit trees, like loquat, mango, lime, lemon, grape fruit, pomello, sweet orange, mandarin, guava, custard apple and grape vines. The planted nursery area covers about $1\frac{1}{2}$ acres and comprises a total of 14,439 saplings of various fruit trees. Over 2,100 saplings were sold to indentors during the year. The planted orchard was inter-cropped and cover-cropped with a view to realising receipts in its pre-bearing stage. In this, and in the remaining garden area, a number of pulse and vegetable crops were grown and about 18,270 lbs. of seeds were produced for sale.

DIVISION OF SOIL SCIENCE & AGRICULTURE CHEMISTRY

A. Agricultural Chemistry :

(i) *Nitrogenous manure*.—Earlier findings on ammonium chloride and ammonium sulphate-nitrate as efficient nitrogenous fertilizers comparable to ammonium sulphate have been confirmed with paddy and wheat crops.

Dipping of roots of paddy seedlings in a paste of soil containing ammonium phosphate indicated beneficial effect on growth and yield.

(ii) *Dicalcium phosphate*.—Citrate-soluble types of phosphatic fertilizers like dicalcium phosphate and semi-acidulated rock phosphate compared well with the water soluble super-phosphate in use at present.

B. Soil Chemistry:

(i) *Plant Composition*.—Pot culture experiments with wheat at different levels of N, P and K showed that the chemical composition of the plant sample at the tillering stage had a direct relationship to the quantity of fertilizers applied and the final yield obtained.

(ii) *Rapid methods of soil analysis*.—The scope of work for advising farmers on the judicious use of fertilizers has been extended and a Soil Testing Laboratory for Rapid Chemical Tests has been set up.

(iii) *Soil conditioners*.—Soil conditioners like Krilium, Aerotil and Poly-ack have been found to improve the soil structure of alkali soils as well.

C. Micro-nutrients :

(i) *Kashmir Soil*.—Two Kashmir soil profiles—saffron growing well in one and not in the other—did not differ in their content of manganese, cobalt, copper and zinc. The soil growing saffron, however, contained higher percentage of available phosphate.

D. Soil Survey :

(i) *General*.—In reconnaissance soil survey carried out in the laterite areas of Malabar and Kanara, it was noticed that the difference in the soils are due to nature of the underlying parent rocks. The high altitude soils of Simla are akin to Alpine humus soils.

(ii) *Rann of Kutch*.—The areas under the Rann of Kutch were classified into those under the influence of sea water or flood water from the study of the distribution of water soluble potassium and magnesium in those soils.

E. Physical Chemistry :

(i) *Clay-humus complex*.—It has been found that the group of clay humus complexes characteristic of fertile soils can be formed by the addition of FYM to montmorillonitic clay while kaolinitic type of clay produces the group present in less fertile soils.

(ii) *Alkali Soils*.—Laboratory studies on the alkaline patches at the Botanical Sub-station at Pusa show that, in many areas in the farm, the stage has reached where the dissolution of the calcium carbonate under any crop cover will not be able to reclaim the patches. The gypsum requirement of these patches increases with the onset of summer and is found to decrease if it is applied in instalments rather than in a single lot.

F. Organic Chemistry :

(i) *Pesticides*.—Work on the preparation of synthetic and natural insecticides and fungicides is continued.

(ii) *Antioxidants*.—Antioxidants have been extracted from *Myristica malabarica* seeds and mace which have shown high activity.

G. Physics :

Spectrographic methods were used in the estimation of micro-elements in soil and plant samples.

H. Biochemistry :

(i) *Quality of wheat and pulses*.—Pure strains of wheat and various pulses analysed for their content of vitamins and amino-acids showed considerable variation among different strains.

(ii) *Foliar application*.—Foliar application of dilute solution of urea at the time of flowering considerably enhanced the yield and protein content of wheat grains.

I. Microbiology :

(i) *Rhizobia*.—Pure cultures of rhizobia were isolated from wild leguminous plants and were classified into well known cross inoculation groups.

(ii) *Cowdung Gas Plant*.—A small size model of village gas plant costing about Rs. 200 has been set up. This plant yielded about 50 cu. ft. of gas per day during summer months.

J. Indo-U.S. Project on Soil Fertility & Fertilizer Use (TCM) :

The work on the Agronomic trials was in progress at 40 different centres with different kinds of nitrogenous and phosphatic fertilizers made available under the Indo-U.S. Technical Co-operation Mission Agreement. Soil Survey work at these 40 centres for drawing the soil map of the areas and for correlation of crop responses with the different soil types was in progress at six zonal centres, namely Delhi, Kanpur, Sabour, Nagpur, Poona and Coimbatore.

Certain modern cartographic equipment have been received for compilation of field data for soil maps. The cartographic laboratory is being set up.

The different new fertilizers like ammonium phosphate, ammonium nitrate, nitrophos, urea and triple superphosphate along with ammonium sulphate were examined for their behaviour during storage at 20 different centres under varying conditions of climate and storage, types of packing materials, etc. It has been found that the alkathene bags over jute bags keep hygroscopic fertilizers like ammonium nitrate and urea in good physical condition. Nitrophosphate showed very poor keeping quality.

K. Radiotracers Investigations in Soils and Fertilizers :

A Radio Tracer Laboratory for work with radio-active isotopes as tracers in soils and fertilizers is being set up with the assistance of the Indo-U.S. Technical Co-operation Mission. Work was started with P^{32} for the determination of phosphorus fertility status of soils. Methods for the estimation of radio-phosphorus in soil extracts and plant materials were standardised. Greenhouse experiments on the response and uptake of phosphorus by oats and paddy from different levels of phosphorus applied as radio-active superphosphate on different soils were carried out. The percentage of phosphorus in the plant derived from the fertilizer applied, varied from 18% to 92% according to the nature of the soil. In pot culture experiments, 48 different soils were used for phosphorus response of Indian soils for wheat and paddy. About 40% of these soils showed great response to phosphate.

ENTOMOLOGY

1. Systematic Entomology

As part of taxonomic studies which are prerequisite to all entomological work a card catalogue of the Indian social wasps, comprising 11 genera and about 230 species including Oriental species was completed. This catalogue besides giving reference to systematics of all species also includes information on synonymy, biology, bionomics, nest instinct and behaviour. Similar work was in progress on an important group of parasitic wasps. Studies on genitalic structures of three species of weevils indicated that certain morphological differences in these organs are useful in specific determination. Investigation was carried out on the morphology and the genital armatures of 20 genera comprising 27 species of grasshoppers. Studies on the specimens of Migratory Locust from South India showed that the femoral denticles which occurred on the upper or dorsal edge of the hind femur and which were normally present in the solitary phase did not occur in the gregarious and transitory phases. A study of the male genitalia of an exotic and an Indian species of pulse beetles which were described as separate species showed that the two species are synonymous.

2. Insect Parasitology

The role of insect parasites and predators in keeping the balance in nature of pests of crops is a well known fact. A search was, therefore, maintained to record new and effective parasites of important crop pests; two species of parasitic wasps were recorded on a species of pea leaf miner and one species of parasitic flies on a sann-hemp caterpillar. The larvae of a grain moth which are extensively used for rearing of parasites when fed with combinations of foods like 'jowar', groundnut flour, and yeast showed better growth than those fed on 'jowar' alone. The egg parasites, *Trichogramma* were fed with sugars, like sucrose, levulose, glucose, and fructose and their longevity and rate of reproduction were studied. It was observed that parasites from Mandya were more vigorous and healthy than those from Nellikuppam (Madras).

Investigations were carried out on the incubation period, larval period and adult longevity of a braconid parasite at various temperatures ranging between 12° – 40° C. and relative humidities, 65% and 85%. Studies on superparasitism of a parasite of *Pyrilla* eggs brought to light that though there might be two eggs in one egg of the host, only one can develop beyond the fourth instar. Experiments on host selection revealed that the females were capable of distinguishing between parasitised and unparasitised eggs and further that they preferred freshly laid eggs in blastula or cleavage stage.

Physiological investigations were carried out on insect egg-shell which presents a very complex problem as regards the structure and also the penetration of chemicals through it. In the case of a braconid parasite it was observed that the chorion is formed of two types of proteinacious materials, the non-resistant exo-chorion and the resistant endo-chorion; further the viteline and fertilization membranes are composed of a non-resistant protein mixed with unsaturated lipid. The endo-chorion on examination was found to be lined on its inner surface with unsaturated lipid. The deposition of this substance takes place in the later stage of the egg development in the ovary and it is completed only after the laying of the egg. In the case of a species of lady-bird beetles, all the three layers, *viz.*, chorion, vitelline and fertilization membranes, are composed of protein; the last two layers as usual contain unsaturated lipid. In this case, however, the unsaturated lipid layer is completely deposited on the inner side of chorion while the ovum is still in the ovary.

3. Ecology and Toxicology

Ecological studies on the 'Phadka' grasshopper showed that when the egg pods were placed in the normal position, *i.e.*, with the apex of eggs facing up in the soil the nymphs after eclosion could easily come out to the soil surface; but if the egg pods were placed in inverted position they could not succeed in finding way to the soil surface though the hatching from some eggs was normal. Thus it was shown that ploughing even after rains is useful for the control of this pest. The well known egg parasite, *Trichogramma*, was reared in Stevenson's screens in humidities 35% and 75% in order to collect data for testing the Biometer prepared for this parasite. Close observations on the habits of the Painted Bug showed that the pest remains in soil for most of the part throughout winter and feeds on mustard pods when temperature ranges from 60° F. to 102° F. Besides its usual food plants, this pest was observed feeding on three other species belonging to quite different families. Studies on the effects of temperature and humidity on the sugarcane stem borer (*Chilo traxa* sp.) showed that development was restricted within the range of 12 to 40° C. and that the pest finds in India, favourable conditions all round the year and that the winter diapause in Northern India is also due to certain physiological condition and not only due to unfavourable temperature and humidity.

Investigations on the effect of temperature on the susceptibility of the adults of a flour beetle to DDT film showed a positive coefficient of mortality between 11 and 20° C., a negative co-efficient from 20 to 30° C. and again positive from 30 to 35° C. In case of chlordane, toxaphene, dieldrin and aldrin there was positive temperature co-efficient in mortality throughout the range tested except that mortality at 11° C. was lower than at 20° C. in all the insecticides.

The comparative toxicity of a number of insecticides was established against several important insect pests. Endrin films proved to be much more toxic to the 1st stage larvae of spotted boll-worms of cotton than insecticides, like DDT, BHC, aldrin, dieldrin, isodrin,

chlordan and toxaphene. Used as dust against hoppers of Desert Locust, parathion proved to be most toxic followed by dieldrin. The relative position of aldrin and *gamma* BHC *vis-a-vis* each other remained uncertain; chlordan, isodrin and endrin proved much less toxic. On the other hand used as injections aldrin proved to be much better than endrin, *gamma* BHC and isodrin and compared favourably with dieldrin. Used as dust against larvae of sann-hemp moth the order of toxicity of different insecticides was found to be **endrin > isodrin > gamma BHC > dieldrin > aldrin**.

The I.C.A.R. Schemes, one on D.D.T. and allied insecticides and the other on control of termites affecting agricultural crops, were working in this Division. Bioassay studies of various insecticides were carried out against the mustard sawfly, khapra beetles and 'Kutra' moths. Observations were also continued on the persistence of organic insecticides and their phytotoxicity under field conditions.

Studies on the effect of different insecticides in the control of termites in sugarcane and wheat crops have shown dieldrin to be a promising insecticide against this pest.

MYCOLOGY AND PLANT PATHOLOGY

A. Plant Pathology

Wheat:

(i) *Rust*.—Four hundred and forty-five samples (442 from wheat and 3 from grasses) of black, brown and yellow rusts were analysed which yielded races 15, 21, 24, 34, 40, 42 and 122 of black rust; 10, 11, 20, 26, 63, 77 (new race), 106, 107 and 108 of brown rust; and 13, 19, 20, 31, A, D and F of yellow rust. The new race 77 of *Puccinia triticina*, which infected the differential varieties Mediterranean and Democrat, hitherto resistant to all the other races of this rust, was collected on the wheat varieties Mediterranean, N.P. 798, N.P. 809, Fund and Botla and was found to be widely distributed in the Punjab, Bihar, Bombay and U. P. The virulent race 122 of black rust was picked up from Delhi and Kulu Valley in the Punjab. Races 21, 40 and 42 of black rust, 10, 20 and 63 of brown rust, and 19 and A of yellow rust were predominant and widely distributed. Two cases of colour mutation in the greenhouse cultures of races 15-C and 194 of black rust were observed.

Muehlenbergia hugelii Trin., a perennial grass growing wild in the Upper Simla Hills, was found to be naturally infected with the yellow rust. *Puccinia triticina* collected on an unidentified grass from Bilingula (Mysore State), infected wheat in artificial inoculations and yielded the common race 63.

Further evidence of oversummering of the rusts in the Nilgris and Upper Simla Hills was obtained. Germination of teleutospores of black rust, formed during winter months in the Upper Simla Hills (altitude 8,000 feet), was secured.

For seedling resistance tests, 20,481 plants of various wheat varieties, their crosses and progeny were tested against the three rusts and their races, and 10 varieties to black rust, 15 to brown rust and 9 to yellow rust were found resistant. More than 1,09,985 adult plants were tested in field after artificial infection with different rusts and promising material selected for further study. Observations were also taken on a large population under conditions of natural infection.

Studies on dissemination of rusts based on slide exposure at 61 Rust Nurseries were continued and at several stations spore showers were noticed long before the recorded dates of rust appearance.

(ii) *Loose Smut*.—Out of 86 wheat varieties tested for their resistance to the disease at Delhi and Simla, 55 remained free from infection and may be considered as promising from the point of view of loose smut resistance.

The wheat variety N.P. 775, artificially inoculated with *Ustilago tritici* and given solar heat treatment, remained completely free from infection, whereas the untreated seed showed 23.5 per cent infection. Samples from the bulk wheat (N.P. 775 and N.P. 781) treated likewise showed 0 to 0.39 per cent infection as against 2.05 to 4.6 in the control.

(iii) *Bunt*.—In the varietal resistance tests against the European Bunt (*Tilletia foetida*), the wheat varieties N.P. 785 and N.P. 786 showed 11.7 and 7.5 per cent infection, respectively, as compared to the remaining 29 varieties where the infection ranged from 50.9 to 93.9 per cent.

The spores of Karnal Bunt (*Neovossia indica*), collected during April, 1954, were successfully germinated in September, 1954, and about 80 per cent germination was obtained in cow dung solution within 10 days at 15°—22 °C. Field and pot experiments conducted at Delhi and Karnal to determine the mode of infection showed that the disease was air-borne as infection could not be obtained through infested seed or soil, whereas 48 per cent infection at Delhi and 88 per cent at Karnal was obtained by inoculating wheat ears in the boot stage.

Barley:

Rust.—Nine rust samples of barley, collected from different parts of the country, were analysed which yielded races 21, 34 and 42 of black rust and race G of yellow rust. None of the barley varieties, tested against a mixture of races of black or yellow rusts in the seedling stage, was found to be resistant. In all, 332 cultures of barley were tested against a complex mixture of all the races of black and yellow rusts in the adult stage and 54 varieties were found to be resistant.

Puccinia hordei Oth., Leaf rust of barley, reported to be rare in India, was isolated from a few rust collections from Delhi, U.P. and Nilgiris.

Sugarcane:

(i) *Red Rot*.—Twenty-eight cultures of *Colletotrichum falcatum*, which included some new isolates from the red-rot epidemic areas of the Punjab, were tested on 10 standard cane varieties for Physiologic Forms study, but no evidence of physiologic specialization within the fungus was obtained. In the varietal resistance tests, 195 and 102 cane varieties were tested by the Plug method and through nodal region, respectively, but no variety was found to be resistant. One hundred and four varieties by the Plug method and 2 by the Nodal Infection method, however, behaved as moderately resistant. Mixture of light and dark type isolates gave more infection than the individual strains or other combinations of these isolates, but no significant increase in infection was obtained when the amount of inoculum was doubled. It was further found that ratoon crop was more susceptible to the disease than the plant crop.

(ii) *Smut*.—In the varietal resistance tests carried out with 72 cane varieties at Delhi and 88 at Karnal, 11 and 25 varieties, respectively, were found to be resistant.

Linseed:

Rust.—Fifty samples of linseed rust, collected from different parts of the country, were analysed and Indian races 1, 2, 3, 4, and 5 (new race) were obtained. The new race 5, first observed from the Punjab collections last year, differed from the existing four races in its reaction on the auxiliary differentials Argentine Selection C.I. 750-I, Bison and Koto. *Linum mysorens* growing wild in the hills of India, was successfully infected with the rust in glasshouse, thus indicating its possible role as collateral host. In the varietal resistance tests with 134 linseed varieties in the seedling and adult stages, 95 proved to be resistant.

Pigeonpea:

Wilt.—Out of 20 pigeonpea varieties tested for their resistance to the disease, N.P. 41 and P. 3-2 in pots, and N.P. 41, C36, C.15 W.E., F.52, P. 18-2, P. 131-1, P. 253 A2, P. 298 A and Brazil in field trial did not develop wilt. The pigeonpea variety N.P. 41 has been found consistently resistant for the last 11 years.

Bajra:

Green-car disease.—Oospore material of *Sclerospora graminicola*, exposed to weathering conditions since October, 1953, gave 25-27 per cent infection, whereas similar material stored in laboratory showed only 1 per cent infection. Material from Bikaner, Jodhpur and Delhi gave 42, 26 and 8.5 per cent infection, respectively. Oospore-infested soil, exposed for weathering since 1951, gave infection again this year without the addition of any fresh inoculum, thus indicating the persistence of infection in soil and germination of oospores in small numbers at varying times.

B. Antibiosis

The *Alternaria solani* assay method for the antibiotic from *Bacillus subtilis* was investigated in detail and standardized. The presence of magnesium in the fermentation broth was found to be the most important factor for the growth and antibiotic production of the bacterium. Solvent extraction with n-butanol and subsequent chromatography on alumina yielded a crystalline product with high antibiotic activity. The biological spectrum of the antibiotic showed that it was chiefly antifungal and antiviral. Among the test fungi, twelve showed "bulb" formation and 5 were markedly inhibited in spore germination. The bulb-forming activity was confined to fungi possessing chitinous cell walls. The activity of the substance was greater in liquid media than in agar cultures.

C. Physiology of Fungi

The importance of interrelationship between the carbohydrate and vitamin nutrition for growth and sporulation of *Lophotrichus ampulus* Benj. was established. Suppression of sporulation by glucose was found to be correlated with greater accumulation of fat in the mycelium. Studies on the mechanism underlying sporulation in the fungus indicated that sucrose was directly converted into glucose-1-phosphate.

D. Fungicides

Replicated field experiments were conducted to determine the relative efficacy of 8 commercial fungicides on the emergence, stand and yield of maize, *bajra*, wheat and barley. In general, different seed dressings showed beneficial effect in the case of maize and *bajra* and increased the emergence and yield of the two crops. Ceresan in the case of maize and Agrosan GN in the case of *bajra* were the most effective fungicides.

E. Bacterial Diseases

Work on yellow slime disease of wheat, leaf spot of pomegranate, brown rot of potatoes and red-stripe of sugarcane was continued. The wheat pathogen *Corynebacterium tritici* was found to be a strain of *C. rathayi* which produced similar symptoms on *Dactylis glomerata*. The pomegranate bacterium was found to be new and was designated as *Xanthomonas punicae* sp. nov. In the case of brown rot of potatoes, *Pseudomonas solanacearum* var. *asiatica* (Erw. Smith) Stapp., which differs from *Pseudomonas solanacearum* Erw. Smith in that it produces acid in cream and litmus milk, was found to be widely prevalent in the country.

F. Virus Diseases

In the tests conducted to determine resistance of the 5 species of *Lycopersicon* to tomato leaf curl through viruliferous white-flies, none was found immune, although *L. peruvianum* continued to show high degree of resistance. *Croton sparciflorus* and *Ageratum* sp. were established as additional hosts of yellow-vein mosaic of *bhindi*, whereas *Abelmoschus manihot* var. *pungens* was immune to the virus. Papaya leaf curl virus was transmitted by the white-fly, *Bemisia tabaci*, and the virus was found to be the same as tobacco leaf curl virus (*Ruga tabaci*). Chilli mosaic and leaf curl viruses were transmitted by *Aphis gossypii* and *Bemisia tabaci*, respectively, the former being a new virus while the latter was the same as tobacco leaf curl. *Brachiaria ramosa*, *Digitaria bifasciculata* and *Setaria verticillata* were found to be additional hosts of maize mosaic virus, while a species of *Toxoptera* was found to be an additional vector. Sugarcane mosaic was transmitted by *Aphis maidis* and *Toxoptera* sp. Sarson mosaic was transmitted by *Macrosiphum granarium* to five *Brassica* spp. A leaf-hopper (*Deltocephalus* sp.) was found to be the vector of sesamum phyllody and it transmitted and virus to *Crotalaria juncea* and *Brassica campestris* var *toria*. Banana mosaic was sap-transmissible to cucumber, but not to banana, bottlegourd or pumpkin. The virus was also transmitted by winged insects of *Aphis gossypii*.

Fundamental studies were carried out on the inhibition of a strain of potato virus X. Extracts of *Capsicum frutescens* as well as the growth products of *Trichothecium roseum* and *Aspergillus niger* inhibited viral multiplication appreciably. *Dolichos* enation mosaic virus was found to be unrelated to tobacco mosaic virus by cross-protection tests.

In the case of little leaf of brinjal, incubation period of the virus in its jassid vector (*Eutettix phycitis*) was finally confirmed to be 8 days and the viruliferous jassids retained the virus throughout their life. The virus of "Katte" disease of cardamom was found to be non-persistent in its vector, *Pentalonia nigronervosa*. The white-fly was able to carry simultaneously three different viruses, namely, yellow-vein mosaic of *bhindi*, yellow-vein mosaic of pumpkin and yellow mosaic of lima beans.

G. Systematic Mycology

Studies in the genera *Alternaria*, *Phyllachora*, *Catacauma* and *Phyllachorella* were undertaken. *Alternaria tenuis* was recorded on 20 hosts. Two species of *Phyllachora* and one of *Phyllachorella* were observed for the first time. Critical taxonomic studies of the genera *Ciliochorella* Syd. and *Plagionema* Subramanian and Ramakrishnan showed that they were synonymous. Seventy other fungi, belonging to the various groups and not recorded earlier, were also studied. These included a new genus of Sphaeropsidales. The perfect stage of the *Macrophoma* sp., causing leaf spot and twig blight of mango, was obtained in culture.

H. General

Investigations on a serious disease of guava in Pushkar Valley, Ajmer, were carried out. The disease was found to be due to zinc deficiency and was controlled by foliage spray of zinc sulphate (zinc sulphate, 1 lb.; hydrated lime, 0.7 lb.; water, 16 galls.).

The paddy straw mushroom (*Volvaria diplasia*) was successfully grown under Delhi conditions during the monsoon season, i.e., from July to early September. The two strains of *Volvaria diplasia*, obtained from Coimbatore and Calcutta, were found to differ in their mushroom-yielding capacity under identical conditions.

3. GENERAL FEATURES OF THE REPORT

(i) LAND AND BUILDINGS

Eight "C" type bungalows were constructed during the year and allotted to Class II Officers. The construction of the second hostel for post-graduate students and Radio Tracer Laboratory and glass house were completed. A major portion of the new area in Todapur was fenced. The construction of the Assembly Hall and of glass houses in the Botany and Mycology Divisions was taken up.

(ii) POST-GRADUATE TRAINING

Fifty-seven students were selected during the year for the regular post-graduate training in different subjects out of a total number of 184 applicants.

Two new courses of study—Rice Agronomy and Agricultural Botany with special reference to Plant Breeding and Genetics in Rice were added.

13 students were given short-course training in different subjects.

11 Honorary Research Workers were admitted to the different Divisions and one M.Sc. student of the Punjab University was given facilities and guidance in his research work.

Forty-eight students successfully completed their studies in the 2-year post-graduate course and were awarded the Associateship of the Institute. A list of the thesis presented by these students is given in Appendix II.

(iii) LIBRARY

The total number of publications received in the Library by exchange and purchase was 4,167. Sixty-seven new periodicals were added to the Library. Out of a total of 6,288 books issued out on loan, 1,256 were sent to the scientific workers in the States and Universities. The Reading Room was used by 8,962 visitors and, 1,46,809 books were consulted.

References to literature on various subjects were supplied to the Ministry of Food & Agriculture, Indian Council of Agricultural Research, State Departments of Agriculture, Universities and to individual scientists. Some of these subjects were :—

The cultivation of sugarcane; soil, soil analysis and water treatment; soil conservation; medicinal plants; economics of cow protection; camel; Plant protection; Hindi publications on vegetable culture.

(iv) ADVISORY WORK

A large number of requests for expert advice and help on agricultural matters both from official and non-official sources was attended to. The types of problems handled are mentioned below :—

Agronomy.—General cultivation practices and distribution of seeds of improved varieties.

Botany.—Identification of plants and fruits, supply of information on a dung yielding plant *Rauwolfia serpentina* and on the cultivation of *Pyrethrum yucca*, and ramie fibre, identification of poisonous weed seeds found in the imported food grains, note on utilisation of sea weeds as cattle feed.

Chemistry.—Analysis of soil, manure and water samples and insecticides. Advice on the suitability of soils for the cultivation of particular crops.

Entomology.—Identification of insect pests, predators and parasites, supply of coloured plates depicting the life history of insects to different workers and institutions, advice on the control of insect pests and rodents, issue of health certificates.

Mycology and Plant Pathology.—Identification of pathogenic and taxonomic specimens and fungal and bacterial cultures, disinfection of samples, issue of health certificates, and calculation of resistance and susceptibility ratings of sugarcane varieties to red rot, supply of fungal and bacterial cultures to research workers and institutions.

Agricultural Engineering.—Selection and source of availability of suitable agricultural implements, supply of blue prints of drawings of implements and machinery and scrutiny of schemes on agricultural machinery.

(v) RESEARCH SCHEMES

Work on the following schemes financed by the Indian Council of Agricultural Research (I.C.A.R.), the Indian Central Oilseeds Committee (I.C.O.C.) and the Government of India, Ministry of Food & Agriculture (M/F & A) was in progress in the different Divisions of the Institute during the year under report :—

Sl. No.	Title of the Scheme	Sponsored by	The Division in which the work was in progress
1	Scheme for the collection of exotic and indigenous pasture grasses and legumes, their testing and distribution, and their breeding for better agronomic characters.	I.C.A.R.	Agronomy and Botany.
2	Scheme for the improvement of maize crop in India .	Do.	Botany.
3	Scheme for the establishment of a nucleus organisation for the introduction of new economic plants.	Do.	Do.
4	Co-ordinated scheme for investigations of micro-nutrients.	Do.	Do.
5	Scheme for the preparation of a monograph on agriculture in ancient India (up to December 31st, 1954).	Do.	Chemistry.
6	Scheme for the research on the examination of rapid methods of soil test for soil survey work.	Do.	Do.
7	Scheme for the studies of the chemical composition and nutritive value of wheat.	Do.	Do.
8	Scheme for tests with DDT, 666 and allied insecticides (up to 31st March, 1955).	Do.	Entomology.
9	Termite research scheme	Do.	Do.
10	Co-ordinated plant virus research scheme	Do.	Mycology

Sl. No.	Title of the Scheme	Sponsored by	The Division in which the work was in progress
11	Scheme for the production, trial and popularisation of improved agricultural implements.	I.C.A.R.	Agricultural Engineering.
12	Key village scheme	M./F. & A.	Agronomy.
13	Co-ordinated Wheat Rust Control Scheme (botanical and mycological portions).	Do.	Botany and Mycology.
14	Scheme for agronomical studies on oilseeds	I.C.O.C.	Agronomy.
15	Scheme for cytological studies on some oilseed crops in India.	Do.	Botany.
16	Scheme for the development of a method to determine the unsaturation of a small quantity of oil.	Do.	Chemistry.
17	Scheme for research on phyllody diseases of sesamum .	Do.	Mycology.
18	Linseed rust scheme	Do.	Do.
19	Scheme for research on the diseases of sugarcane	I.C.S.C.	Do.
20	Scheme for agronomic trials of fertilizers	T.C.A.	Agronomy and Chemistry.
21	Scheme for the determination of soil fertility and fertilizer use.	T.C.A.	Chemistry.

(vi) COLLECTIONS AND HERBARIA

The foreign plant introduction and indigenous collection during the year numbered 1,457 and 969 items, respectively, bringing the total collection to 11,971 items. Further progress was made in the evaluation and utilisation of some of the newer introductions. One hundred specimens were added to the herbarium maintained at the Botany Division. The number of specimens now totals 5,500.

Twenty-one cultures of fungi were added to the Indian Type Culture Collection at the Mycology Division, thus bringing the total number of cultures in stock to 956. About 5,000 subcultures of fungi and bacteria were made on different media for their maintenance. Two thousand and forty-two mycological specimens, which included some important foreign exsiccati sets were added to the Herbarium, raising the accessions to 22,684. More than 100 specimens and several coloured plates were supplied to scientific workers and teaching institutes. Fascicle II of "Indian Uredinales" and Fascicle I of "Indian Ustilaginales" were issued to 16 important foreign herbaria. A list of Phyconeycetons specimens present in the Herbarium was prepared for distribution.

During the year, 59 species comprising 118 specimens belonging to 34 genera of family chrysomelidae (coleoptera), 80 species comprising 3,141 specimens belonging to 34 genera of various families of Hymenoptera and two specimens of *Patanga japornica* (Orthoptera) were added to the National Pusa Collection maintained at the Division of Entomology. Four specimens of *Caryedon fuscus* Goeze and 6 specimens of *Callosobruchus rhodesianus* Pic of family Bruchidae were received from England in exchange of Indian insects.

(vii) INTENSIVE CULTIVATION SCHEME

Considerable progress was made in the development of 19 villages which were taken up in August, 1950. A total of 696 demonstrations were arranged concerning the use of new varieties, manures and fertilizers, improved cultural practices and better implements and the application of insecticides and fungicides. Area sown with New Pusa rust resistant wheat varieties was 1,095 acres, major part of which was under N.P. 718, an early-maturing low water-demanding variety which yielded $2\frac{1}{2}$ mds. per acre more than the local variety. About 2,900 mds. of nucleus seed of N.P. 718 was supplied to Rajasthan and Madhya Bharat Departments of Agriculture. Other varieties recommended were barley N.P. 15, oats N.P. 1, gram N.P. 58, tobacco N.P. 219 and 220, peas N.P. 29, sugarcane Co. 647, *bajra* T 55 and sweet potato FA 17. Locust control was special feature of work this year. Villagers took prominent part in Indian Agricultural Research Institute Golden Jubilee Celebrations. A survey was conducted on the general agricultural conditions and fodder requirements in the Key Villages under a scheme.

About 1,063 mds. of improved varieties of seed of wheat, oats, peas, berseem, maize, cowpeas and other crops were distributed, in addition to 1,145 seed samples of grasses and legumes, and 240 crowns of Kudzu Vine.

As in previous years control measures were carried out in these villages against major pests and diseases. Regular surveys of important diseases and pests as well as an appraisal of losses caused by them were conducted.

(viii) MEETINGS AND CONFERENCES

As usual, the Director, the Heads of Divisions and other officers of the Institute attended the meetings and conferences held under the auspices of the various Ministries of the Government of India, Indian Council of Agricultural Research, various Commodity Committees, etc.

(ix) SUPPLY OF PEDIGREE AND STOCKS

As in previous years, the demand for N.P. seeds, especially of wheat, from the different States was quite heavy and it was not found possible to meet it in full on account of limited area available for seed multiplication. The following quantities of pedigree N.P. seeds of different crops were supplied by the Institute and a sum of Rs. 24,614/8/- realised from the sale.

Crop	Quantity of seed distributed (in maunds)
Wheat	1,255.67
Oats	32.50
Barley	32.25
Maize	16.85
Linseed	4.07
Gram	7.00
Peas	37.85
Other crops	7.40
Seed Potato	104.00
Sugarcane	1,025.07

During the year under report, two cows and nine young male stock were sold for Rs. 7,030. The 30-acre garden area was systematically laid out and several varieties of fruit trees like loquat, mango, lime, lemon, grape fruit, pomello, sweet orange, mandarin, guava, custard apple and grape vines were planted in 16 acres. Over 2,100 saplings were sold to indentors this year.

(x) VISITORS

A large number of distinguished Scientists both from India and abroad as well as Members of Parliament and high officials of Central and State Governments visited the Institute. Shri Jawaharlal Nehru, H.E. K. M. Munshi, late Shri Mavalankar, Prime Ministers of Egypt, Sudan and Yeman, Dr. P. V. Cardon, Director General of F.A.O. of the U.N. require special mention.

Part II

REPORTS OF THE HEADS OF DIVISIONS

REPORT OF THE DIVISION OF AGRONOMY (INCLUDING AGRICULTURAL RESEARCH SUB-STATION, KARNAL)

(Dr. T. J. Mirchandani)

I. WEATHER AND ITS EFFECTS ON CROPS

The records of the meteorological observations are summarised below :—

Month	Temperature		Mean mini- mum °F	Depart- ure from normal	Rela- tive humidity at 7 a.m. (Local) %	Rainfall in inches	Depart- ure from normal	Mean wind velocity in M/H	Mean hours of bright sun- shine	Mean evapo- ration in inches per day
	Mean maxi- mum °F	Depart- ure from normal								
July, 1954 . . .	97.7	+2.0	80.6	-0.1	80.4	12.05	+4.20	4.88	6.67	0.3897
August, 1954 . . .	94.8	+2.6	79.1	+0.1	77.9	0.89	-4.52	4.39	6.98	0.3421
September, 1954 . . .	92.7	0.0	77.5	+2.8	83.5	4.68	-0.26	3.33	7.76	0.3162
October, 1954 . . .	85.7	-6.4	59.0	-4.5	82.0	8.25	+7.85	1.60	9.37	0.1713
November, 1954 . . .	81.6	-1.1	48.9	-1.0	79.9	Nil	-0.05	1.02	9.50	0.1383
December, 1954 . . .	72.5	-0.3	41.3	-1.8	86.8	Nil	-0.08	0.94	8.70	0.0579
January, 1955 . . .	67.6	-1.5	43.2	+0.8	91.4	1.15	+0.42	1.42	6.70	0.0805
February, 1955 . . .	75.1	+0.9	48.4	+1.8	81.8	0.04	-0.75	2.31	9.32	0.1588
March, 1955 . . .	88.5	+4.0	57.7	+2.7	72.1	0.09	-0.73	3.07	8.33	0.2794
April, 1955 . . .	94.1	-3.5	60.5	-6.2	43.2	0.37	+0.14	3.33	9.47	0.3931
May, 1955 . . .	100.7	-3.7	72.6	-4.2	43.0	0.24	-0.25	4.94	9.91	0.5391
June, 1955 . . .	104.8	0.0	82.3	-0.3	52.7	2.46	+1.17	6.17	7.05	0.6228

The monsoon broke on the 10th July, 1954. Precipitation during August was scanty and much below the normal. This coupled with high temperature necessitated irrigation of all the standing crops. The monsoon continued up to October and this helped in the growing of most of the *rabi* crops without pre-sowing irrigation. The winter rains amounted to 1.28 inches. Comparatively low temperature prevailing from October to January adversely affected the growth of berseem. However, continued low temperatures in April and May prolonged the growth period of berseem and this compensated for the initial set back suffered by this crop. There was severe ground frost in January which affected potato, brinjal, chillies and tomatoes adversely. Locust swarms visited the farm for five days in July and August. No damage was done to the standing crops, as the swarms were driven away.

The yields of principal crops grown on the farm are given below :—

Crop	1954-55		1953-54
	Area	Average yield per acre (maund)	Average yield per acre (maund)
Wheat	86.02	21.66	16.66
Oats	46.12	21.23	18.44
Peas	22.43	16.78	15.45
Gram	7.70	5.44	5.56
Berseem fodder	14.25	529.20	485.42
Maize	21.74	14.00	12.19
Sugarcane	8.96	697.90	479.17

A comparative statement of irrigation costs for the years 1952-53 to 1954-55 are given below :—

Year	Area irrigated (acre)	Irrigation charges paid (Rs.)	Irrigation cost per acre (Rs.)
1952-53	1651.98	89,020.86	53.50
1953-54*	1413.50	65,922.50	46.50
1954-55†	1125.86	46,590.00	41.38

*Excluding figures for February and March, 1954 for which bills have not been received.

†Excluding figures for August and December 1954 and January, May and June 1955 for which bills have not been received.

II. RESEARCH PROJECTS

1. Soil fertility building experiments

(i) *Building up of soil fertility through organic manures and inorganic fertilizers with and without a legume in the rotations.*—The rotations followed were : (a) maize-wheat-maize-wheat and (b) maize-wheat-peas. During the year under report, maize and wheat were grown in both the series after completion of one cycle of the rotations. With maize in both the series, NP, NPK and castor-cake gave significantly higher yields (17.1 to 25.7 md.

per acre) than F.Y.M. and the control (12.7 to 17.9 md. per acre) treatments. With wheat, NP and NPK showed significant effect (27.3 to 30.8 md. per acre) over other treatments (17.8 to 24.9 md. per acre). Organic manures which were applied only to maize did not show significant residual effects on wheat. The yields of maize and wheat in the legume rotation were higher than those obtained under the cereal rotation. The experiment remains in progress for studying the possibility of maintaining soil fertility under these rotations with adequate manuring.

(ii) *Building up of soil fertility through organic manure and inorganic fertilizer.*—The object of this experiment is to examine the possibility of growing two cereal crops, viz., *bajra* and wheat in the same year, in conjunction with manuring, under irrigated conditions. *Bajra* grown after fallow gave significantly higher yield (17.5 md. per acre) than *bajra* grown after wheat (15.2 md. per acre). As regards different doses of F.Y.M., that of 20 tons per acre gave significantly higher yield of *bajra* (8.9 md. per acre) as against 15.1 to 16.7 md. per acre for lower dose. Differences among the levels of nitrogen 0, 20 and 40 lb. per acre as ammonium sulphate were significant (15.0, 16.5 and 17.6 md. per acre). The response per lb. of nitrogen for 20 and 40 lb. levels were 6.0 and 5.2 lb. of grain yield. Similar results were also obtained with wheat. Wheat after fallow gave 25.5 md. as against 13.1 md. after *bajra*. F.Y.M. at 20 tons per acre showed significant differences over 0, $2\frac{1}{2}$ and 5 tons per acre levels (20.5 against 17.7 to 18.9 md. per acre). So far high yields of these crops have not been obtained under intensive cropping and manuring.

(iii) *Building up of soil fertility through organic manures, including green manure and inorganic fertilizers.*—The third cycle of the rotation, GM-wheat-maize-wheat was started during the year under report. Green manuring with *guar* gave highest yield of 25.2 md. but the extra return was not significant over the treatments of castor-cake, F.Y.M. and control. Similarly, the effects of N, P, NP and NPK treatments were not significant.

(iv) *Building up of soil fertility through green manure with and without phosphate and micro-nutrients.*—Green manuring with *guar* in conjunction with phosphate, boron and molybdenum gave highest yield of wheat (23.7 md. per acre) and this was significant over the treatment '*guar* grown, but harvested' and 'no green manure' which respectively gave yields of 17.4 and 15.6 md. per acre.

(v) *Building up of soil fertility through phosphate manuring of legumes: effect of low doses of phosphate.*—The third cycle of the rotation: berseem-cowpeas (3 years) followed by wheat after fallow and cowpeas (3 years), was started during the year under report. In regard to green fodder yield of berseem, the treatments of superphosphate 64 lb. P_2O_5 , FYM 8 lb. P_2O_5 plus superphosphate 56 lb. P_2O_5 and F.Y.M. 56 lb. P_2O_5 plus superphosphate 8 lb. P_2O_5 per acre gave significantly higher yields (555.04, 481.4 and 463.9 md. per acre) than 0, 16 and 32 lb. P_2O_5 levels. The yield of seed obtained after four cuts of berseem showed significant responses to 64 lb. P_2O_5 applied as F.Y.M. and superphosphate singly and in combinations. These results confirm the benefit of the phosphate manuring of berseem as reported earlier.

(vi) *Building up of soil fertility through phosphate manuring of legumes: effect of phosphate with and without potash and/or nitrogen.*—This experiment is being conducted in two series; (a) Berseem (fertilized)—cotton-wheat-fallow—berseem (fertilized)—maize; (b) berseem (fertilized)—maize-berseem-cotton-wheat-fallow. During the year under report maize-berseem (fertilized) were grown in series (a) and fallow-berseem (fertilized) in

series (b). In series (a), the residual effect of fertilized berseem on maize was significant (25.3 to 28.0 md. per acre) over the control in which berseem had not been fertilized (22.2 md. per acre). In regard to the berseem yields under both the series, fertilizing with P, PK, NP and NPK treatments produced significantly higher yields than the control. The effect of potash and nitrogen was not marked as compared to PK and NP treatments respectively.

(vii) *Building up of soil fertility through phosphate manuring of Hubam clover.*—Hubam clover did not respond to phosphate manuring. The doses of P_2O_5 applied were 0, 40, 80 and 120 lb. per acre. Maize is being grown to study the after effects.

2. Rotation experiments

(i) *Comparative effects of different systems of rotations.*—Sixteen rotations of different intensities, including fallowing and green manuring were tested under irrigated conditions. The experiment is now in the fourth year and it is too early to draw any definite conclusions.

(ii) *Economics of different rotations.*—G.M.-wheat rotation gave a net return of Rs. 264.7 per acre, while maize-wheat gave Rs. 174.2, fallow-wheat Rs. 218.2 per acre.

3. Response to manures and fertilizers

(i) *Response curve of nitrogen with wheat.*—Nitrogen doses varying from 20 to 100 lb. per acre gave significant response over the control (30.5 to 35.5 md. per acre; control 25.7 md. per acre). The effect of P_2O_5 alone was significant over the control, but its combined effect with nitrogen was not significant over nitrogen alone.

(ii) *Effect of F.Y.M. and ammonium sulphate at different levels on wheat.*—As reported last year, F.Y.M. appeared to have little nitrogen value when used alone (10.2 to 12.8 md. per acre). F.Y.M. in combination with ammonium sulphate gave fair response (14.6 to 18.0 md. per acre). Ammonium sulphate alone at 60 lb. N per acre gave the highest yield (19.4 md. per acre).

(iii) *Optimum time of application of some nitrogenous fertilizers to wheat.*—Differences among the different types of fertilizers, viz., ammonium sulphate, ammonium nitrate, Chilean nitrate and urea were not significant (35.5 to 36.4 md. per acre). In regard to the time of application, it was observed that when fertilizers were applied in full dose at sowing, the crop lodged badly and the yields were lowered. Late applications, 4-8 weeks after sowing, or fractional applications gave significantly higher yield per acre.

(iv) *Optimum time of application of F.Y.M. to wheat.*—Time of application varying from 1 week to 3 months before sowing wheat, did not show significant effect on the yield of wheat (14.2 to 16.0 md. per acre), but the indications were in favour of early applications.

(v) *Value of compost.*—This experiment was conducted in collaboration with the Chemistry Division. Compost manures prepared by different methods, viz., plastered trench, overground heap and exposed pit were tested in a field experiment on maize and wheat. As reported last year, differences among the manures were not significant.

(vi) *Effect of wheat straw buried with and without artificials on wheat.*—This experiment was also conducted in collaboration with the Chemistry Division. Like last two years the response was not significant as compared to the yields obtained from plots in which straw had not been buried (21.5 to 24.9 md. per acre).

(vii) *Effect of 'Soilneed' type of fertilizer on wheat.*—This imported complete fertilizer (NPK) received for trial was tested against equivalent doses of N, NP and NPK, applied as ammonium sulphate, superphosphate and potassium sulphate. Differences among 'soilneed' type fertilizer, NP and NPK were not significant (28.7 to 33.3 md. per acre). All these treatments showed significant response over the control (22.7 md. per acre) treatment.

(viii) *Effect of different types of phosphates on berseem.*—This experiment was conducted in collaboration with the Chemistry Division. Superphosphate alone and the combinations with rock phosphate and Trichy nodules gave significantly higher yields (782.1 to 860.7 md. per acre), than rock phosphate, bone meal and Trichy modules (493 to 694.0 md. per acre) applied separately to the berseem crop.

(ix) *Response of Huban clover and senji mixture to phosphate manuring.*—As noticed in the previous years' response to phosphate manuring was not significant. Hubam clover alone and its mixture with *senji* gave significantly higher yields (261.9 to 314.2 md. per acre) than *senji* alone (213.0 md. per acre).

(x) *Manurial-cum-varietal trial on tobacco.*—The effect of F.Y.M. at the rate of 0, 5 and 10 tons per acre was not significant (19.5 to 21.0 md. per acre), but the effect of ammonium sulphate at 40 and 80 lb. per acre was significant over the control treatment (20.9 and 21.1 md. per acre as against 18.2 md. per acre for the control). N.P. 219 gave significantly higher yields (22.9 md. per acre) than N.P. 218 and N.P. 220. The interactions were not significant.

(xi) *Manurial-cum-varietal trial on sugarcane.*—The effect of nitrogen doses of 40, 80 and 120 lb. N. per acre was significant (788.4 to 812.2 md. per acre) over the control (747.5 md. per acre) treatment. The varietal differences were also significant. Co. 647 gave highest yield (919.0 md. per acre) and this was followed by Co. 797, B0 11, Co. 659, Co. 312 and Co. 739 in order of merit. The interaction was not significant.

4. Cultural experiments

(i) *Cultivation-cum-manurial experiment in a rotation of maize-berseem-fallow-wheat.*—This experiment has been in progress for the last five years. As reported last year, the results showed no significant differences between deep and shallow ploughings. With maize, the yields ranged from 12.2 to 14.2 md. per acre and with wheat from 28.8 to 33.2 md. per acre.

(ii) *Cultural-cum-manurial experiment on maize.*—Frequency of ploughings (2 to 6) did not show any significant differences in the yield of maize. As regards interculturalings, 3 hoeings gave significantly higher yield (12.5 md. per acre) than one hoeing (9.4 md. per acre) or removal of weeds by hand (9.7 md. per acre). Further, placement of fertilizer at plough-sole was significantly superior (11.9 md. per acre) to broadcasting, (10.2 md. per acre) or placing in the lap of furrow (9.6 md. per acre). Similar results were obtained in the previous years.

(iii) *Cultural-cum-manurial experiment on groundnut and pigeonpea.*—This experiment was started during the year under report. In this experiment also with pigeonpea, deep ploughing did not show significant superiority over shallow ploughing. 10 ft. spacing gave significantly higher yield (15.6 md. per acer) than 6 ft. spacing (11.1 md. per acre). Again, broadcast application of fertilizer gave significantly more yield (14.1 md. per acre) than placement in rows (12.6 md. per acre). The groundnut crop failed due to fungus diseases.

(iv) *Cultural-cum-manurial experiment on potatoes and carrots.*—These experiments have been in progress for three years. Depth of cultivation treatments have not shown significant differences in yields of potatoes and carrots. Balanced manuring with NPK gave significantly higher yields than manuring with N alone. Broadcast application of fertilizers gave higher yields than placement at plough sole. These results generally confirm the previous years' results.

(v) *Cultural-cum-manurial experiment on cotton.*—The results were similar as reported last year. Deep ploughing did not show significant effect as compared to shallow cultivation with *desi* plough (15.1 to 16.5 md. per acre). The effect of manuring with ammonium sulphate and groundnut cake singly and in combination with phosphate was not significant.

5. Weed control experiments

(i) *Weedicide-cum-manurial experiment on sugarcane.*—This experiment has been in progress for two years. Mechanical weeding gave significantly higher yields of cane (629.3 md. per acre) than copper sulphate and Dicotox (2, 4-D) treatments (515.7 and 512.9 md. per acre). Manurial treatments did not show significant effect.

(ii) *Weedicide-cum-cultural experiment on Sorghum halepense (Baru).*—*Baru* is a perennial pernicious weed in the cultivated area. TCA and CMU were tried against digging with spade and deep and shallow ploughing for the control of this weed. Effect of cultural operation will be seen next year. Between TCA and CMU, the latter was found more effective. The mortality due to CMU treatment was found to be 70-80 per cent.

6. Irrigation experiments

(i) *Irrigation-cum-manurial-cum-varietal experiment on wheat.*—Two and three irrigations gave significantly higher yields (23.0 and 24.0 md. per acre) than one irrigation (20.3 md. per acre). Manurial treatments were not significant. N.P. 718 and N.P. 775 gave significantly higher yields (23.3 and 23.1 md. per acre) than N.P. 710 (21.0 md. per acre). Interactions were not significant. The results need confirmation next year.

(ii) *Irrigation-cum-manurial experiment on berseem.*—Results obtained during the year generally confirmed those of the previous years. Fourteen irrigations, each of 3 inches depth gave significantly better results (1038.6 md. per acre) than 10 irrigations (939.0 md. per acre). The effect of P and NP was also significant over the control. The highest yield of berseem fodder was obtained from 30 lb. N plus 120 lb. P_2O_5 per acre (1109.2 md. per acre).

(iii) *Irrigation-cum-cultural-cum-manurial experiment on sugarcane.*—Unlike the results reported last year, the main effects and interactions were not significant. The experiment is being continued.

7. Varietal trials

Hybrid maize Texas 26 and North Carolina gave significantly highest yields (35.3 and 34.9 md. per acre). Among *bajra* varieties, Pb. T/55 and B.207 (Bombay) gave highest yields (9.6 and 9.1 md. per acre). In a wheat varietal trial with 25 varieties, N.P. 792, N.P. 710, N.P. 797 and C. 591 showed high yields (25.4 to 26.6 md. per acre), while N.P. 771, N.P. 737 and N.P. 745 showed low yields (12.7 to 16.7 md. per acre).

8. Agrostology

Among grasses, *Setaria sphacelata*, *Brachiaria mutica*, *B. brizantha*, *Pennisetum pedicellatum* and *P. polystachyum* showed good performance. Of the legumes, *Desmodium purpureum*, *D. scorpiurus*, *D. tortuosum*, *D. uncinatum*, *Phaseolus lathyroides*, *Lupinus termis* and *Mucuna cochinchinensis* were found to be promising species.

As reported last year, maize was grown successfully after wheat and Hubam clover mixture. From the trials conducted during past three years, an average yield of 15 md. wheat and 17 md. per acre of maize were obtained from the same plot. By growing a mixed crop of wheat and *Vicia sativa*, the yield of wheat recorded was 28 md. per acre, against the average yield of 20 md. per acre. The yield of wheat *bhusa* was also increased by 25 per cent. Further, the legume mixture enriched the quality of wheat *bhusa* in respect of protein content, as both were harvested together. Other useful mixtures were oats-*Vicia sativa*, Napier grass-kudzu vine, Rhodes grass-lucerne and *anjan* grass (*Cenchrus* sp.)—lucerne.

(i) *Flat carrying capacity of pasture crops*.—The object of these studies is to determine the carrying capacity of some pasture crops, viz., kudzu-vine, Rhodes grass, *anjan* grass (*Cenchrus ciliaris*), *apang* (*Dichanthium annulatum*) and Blue Panic. During the year under report, two grasses, viz., *anjan* and *apang* showed carrying capacity of 0.67 and 0.52. Blue Panic did not respond to grazing. The experiment remains in progress.

(ii) *Manurial-cum-cutting trials*.—With Blue Panic (*Panicum antidotale*), the interval of cuttings, 20, 30 and 40 days did not show significant differences in the yield (216.7 to 234.6 md. per acre). The response to nitrogen levels was significant. 120 lb. N. per acre produced 262.9 md. per acre green fodder as against 183.3 md. per acre from the control. With *Vicia sativa*, the differences between one and two cuts were significant in favour of one cut (239.8 md. per acre). The response to phosphate was also significant, 80 and 120 lb. P_2O_5 per acre significantly increased the yield (235.4 to 239.7 md. per acre) over the control treatment.

9. Agronomic experiments to study the incidence of wheat rusts

Agronomic experiments were conducted at the I.A.R.I., New Delhi and the Botanical Sub-station, Pusa to study the effect of agronomic practices, viz., dates of sowing, effect of N, P and K fertilizers at different levels and combinations, irrigation and mixed cropping, on the incidence and intensity of wheat rusts. Observations were taken in collaboration with the Mycology Division. At New Delhi, the intensity of rust was greater in plots treated with high doses of nitrogen (40 lb. and above) than those plots which were given no manure or light dose of nitrogen. The effect of N was more marked than P or K. In irrigation experiment, with three irrigations and 40 lb. N per acre, the rust incidence was

greater than in other treatments. December sowings (10th and 20th) showed heavier infection than earlier sowings. Under mixed cropping, no differences in rust incidence was observed. At Pusa, in the irrigation experiment incidence of black rust was light to moderate in 'no irrigation'; but light to heavy in 1 to 2 irrigations. In other experiments, no differences were observed in respect of rust incidence on the wheat crop.

10. All India scheme on fertilizer experiments

Fertilizer experiments on paddy were in progress at 19 centres. During the year 60 complex experiments at 9 centres and 850 simple cultivator field experiments at 10 Community Project centres were conducted. The responses to 20 and 40 lb. levels of nitrogen were 3.22 md. and 5.21 md. of extra paddy yield per acre. Ammonium sulphate and urea practically showed similar performance on equal nitrogen basis. The responses to 20 and 40 lb. levels of P_2O_5 were 1.43 and 3.16 md. respectively. High response to nitrogen was indicated on alluvial soils, grey and brown soils and medium black soils; moderate response on laterite, red loam, deltaic and saline soils; and, low response on coastal alluvium, red gravelly and mixed red and black soils. Similar phosphate response has also varied in relation to soil type. The interaction between nitrogen and phosphate has not proved significant which indicates that the effects are independent of each other. Time of application and methods of application did not show significant differences amongst the treatments.

The data for 1953-54 wheat crop were compiled late in 1954 as it took time to receive necessary information from all the research centres. Experiments were conducted in 12 Community Project centres and 8 complex experiment centres. The number of experiments conducted at the two type of centres were 958 and 33 respectively. The responses to 20 and 40 lb. nitrogen doses were 2.3 and 3.10 md., respectively. The second dose of nitrogen was less remunerative than the first dose. Responses to 20 and 40 lb. doses of P_2O_5 applied as superphosphate were 1.90 and 3.60 md. Response to potash was small. Response varied very highly in relation to soil type. Irrigation increased the responses to nitrogen and phosphate by 33%. The nature of response up to 40 lb. level of N and P_2O_5 , on most of the soils was linear.

11. Oil seed scheme (I.C.O.C.)

Varietal trials, mixed cropping and manurial experiments were carried out on sesamum and linseed. The sesamum crop failed due to excessive rains and gale at maturity. Among linseed varieties T. 477 (U.P.) gave highest yield (155 md. per acre) and this was followed by N.P. 12. In mixed cropping experiments pure crops gave significantly higher yields than the mixed crops. The results are in conformity with those of last year. The effect of micro-nutrients on linseed was not significant, but manganese sulphate together with NP gave highest yield (22.6 md. per acre). This experiment was started during the year under report.

12. Grass scheme (I.C.A.R.)

The scheme for the collection of indigenous and exotic grasses and legumes, their testing and distribution, which was started in February, 1953, continued to function. 28 grasses were added to the collection during the year under report.

13. Agronomic experiments at Pusa

(i) Permanent manurial and rotation experiments.—The results are given below :—

Yield of grain per plot in lb. (1/4 acre plot)

Sl. No.	Treatment per acre	"A" Series		"B" Series		
		Maize	Peas	Maize	Barley	Wheat
1	No manure (Check No. 1)	104		41	67	..
2	F. Y. M. 4000 lb.	172		189	214	..
3	F. Y. M. 8000 lb.	279		203	311	..
4	F.Y.M. 4000 lb.+rape-cake 20 lb. N	265		160	337	..
5	Rape-cake 40 lb. N	219		95	200	..
6	Amm. sul. 40 lb. N	133		80	50	..
7	Pot. sul. 50 lb. K ₂ O	120		84	62	..
8	Super. 80 lb. P ₂ O ₅	152		99	138	..
9	Super. 80 lb. P ₂ O ₅ +pot. sul. 50 lb. K ₂ O.	184		118	113	..
10	Amm. sul. 40 lb. N+super. 80 lb. P ₂ O ₅ +pot. sul. 50 lb. K ₂ O.	156		162	174	..
11	Amm. sul. 40 lb. N+super. 80 lb. P ₂ O ₅ .	115		60	281	..
12	Green manure in conjunction with purely cereal rotation.	G.M.	The crop failed due to late sowing.	G.M.	..	55
13	No manure (Check No. 2)	58		40	53	..
14	Amm. sul. 40 lb. N+pot. sul. 50 lb. K ₂ O.	57		44	128	..
15	Effect of green manure and leguminous crop in rotation.	124		G.M.	78	..
16	As in plot No. 15+super. 80 lb. P ₂ O ₅	148		G.M.	204	..
17	No leguminous crop and no green manure.	20		2	..	25
18	No manure (Check No. 3)	2		Failed	129	..

With maize, F.Y.M., F.Y.M.+rape-cake, rape-cake (A series) and NPK treatments gave good yields, P and PK under 'A' series also showed good response. With barley, organic manures, NP, G.M.+superphosphate showed good yields.

(ii) *New manurial experiments.*—The results of this experiment were as follows:—

Treatment per acre	Maize md./acre	Wheat md./acre
A. No manure	7.75	5.20
B. F.Y.M. 40 lb. N	16.65	7.54
C. Rape-cake 40 lb. N	15.27	5.85
D. Amm. sul. 40 lb. N	11.96	6.91
E. Pot. sul. 50 lb. K_2O	8.88	5.39
F. Super. 80 lb. P_2O_5	8.86	5.75
G. Super. 80 lb. P_2O_5 +pot. sul. 50 lb. K_2O	6.16	4.87
H. Amm. sul. 40 lb. N+super. 80 lb. P_2O_5 +pot. sul. 50 lb. K_2O .	12.60	7.28
I. Amm. sul. 40 lb. N+super. 80 lb. P_2O_5	12.15	7.19
J. Amm. sul. 40 lb. N+pot. sul. 50 lb. K_2O	11.24	7.07
“F” test	Significant at 1% level.	
C.D. (5%)	4.22	1.30

In this experiment also, organic manures, N, NP, NK and NPK showed good responses in both the crops.

(iii) *Field experiment to determine the nutritional requirements of Pusa soil.*—This experiment has been in progress for the last three years. In all the years, the results showed that the micronutrients (Zn, Mn, Cu, Fe, Mg, Bo and Mo) had no significant effect on the yield of paddy.

III. SEED DISTRIBUTION

Seeds of improved varieties of crops were distributed as given below :—

Crop	Quantity (md.)
Wheat	993.51
Oats	12.75
Peas	34.24
Berseem	1.96
Maize	16.86
Cowpeas	1.03
Other crops	2.28
Sugarcane setts	1025.33
Grasses and legumes	1145 seed samples.
Kudzu vine	240 crowns and 61 potted plants.

IV. FARM ECONOMICS

Cost studies of ten principal crops grown on the farm during the year 1951-52 and 1952-53 were completed. The cost of producing per acre and per maund of produce, minus irrigation charges are given below :—

Crop	1951-52			1952-53		
	Per acre	Per md.		Per acre	Per md.	
	Rs.	Rs.	As. P.	Rs.	Rs.	As. P.
<i>Jowar</i> (fodder)	100·18	0	8 9	124·66	0	11 0
Maize and cowpeas (fodder)	173·14	0	12 0	195·15	0	12 0
Maize	215·11	9	5 0	354·54	22	0 9
Sugarcane	483·31	1	4 0	468·77	1	7 0
Wheat	240·10	14	10 6	318·45	11	1 6
Oats	187·84	5	5 6	218·74	7	8 9
Berseem (fodder)	273·28	0	10 6	352·53	0	9 9
Peas	245·02	21	6 0	232·06	16	15 9
Barley	186·11	6	5 6	184·53	4	9 6
Gram	210·10	24	1 6	155·43	17	10 3

V. INTENSIVE CULTIVATION SCHEME

The demonstrations arranged in the Intensive Cultivation Scheme area were 696. Thus 30 demonstrations per village were arranged. Area sown with New Pusa rust resistant wheat varieties was 1,095 acres, major portion of which was monopolised by N.P. 718, an early maturing low water demanding variety which yield 2½ md. extra over the local. About 2,900 md. of nucleus seed was supplied to the Rajasthan and Madhya Bharat Departments of Agriculture. Other varieties recommended were barley N.P. 13; oats N.P. 1; gram N.P. 58; tobacco N.P. 219 and 220; peas N.P. 29; sugarcane Co. 647; *bajra* T. 55; and sweet potato F.A. 17. Besides, demonstration on green manuring and fertilizers, those on the control of pests and diseases and improved implements were arranged. Locust control was special feature of work this year. Villagers took part in the I.A.R.I. Golden Jubilee celebrations.

VI. CATTLE BREEDING AND MANAGEMENT

(i) General.—It has now been decided to build up the Sahiwal herd from the existing stock. The strength of the herd on the 30th June, 1955 was 64 head, as against 53 at the close of the last year. The herd consisted of 28 cows, 3 stud bulls, 5 young male stock, 11 young female stock, 6 male calves and 11 female calves. The animals in general maintained good health.

(ii) *Milk yield*.—The wet and overall averages during the year under report were 23·2 and 15·9 lb. respectively, as against 23 l and 13·5 lb. recorded last year. Out of 19 cows which

completed their lactations during the year, 3 did over 9,000 lb. 2 over 8,000 lb., and 8 over 7,000 lb. milk yield per lactation period of 306 days.

(iii) *Calf rearing*.—Ten male calves and 14 female calves were born during the year. Their average birth weights were 59.2 and 56.7 lb. respectively. There was no mortality among the pail-fed calves. The growth rates were 1.1 lb. per head per day for the male calves and 1.2 lb. per head per day for the female calves.

(iv) *Early maturity experiment*.—Records of ten early maturity heifers together with those of adult cows are given below :—

Description of cattle	No.	Age at 1st calving			Average milk yield per lactation (lb.)		
		Y.	M.	D.	I	II	III
First calvers	10	2	7	22	6,181	..	..
Adult cows	9	2	5	26	6,221	6,016	8,074

The drop in the average yield of the adult cows in the second lactation is due to very poor yield given by one cow after abortion.

(v) *Sale of cattle* Two cows and 9 young bulls were sold during the year and fetched Rs. 7,030.

VII. KEY VILLAGE SCHEME

The scheme has not started functioning on full scale. The Veterinary Assistant Surgeon has been sent to the I.V.R.I. to undergo three months' training in the methods of artificial insemination. A survey was made on the general agricultural conditions and fodder requirements in Key Villages.

VIII. PROGRAMME OF WORK FOR THE YEAR 1955-56

(i) *Soil fertility building experiments*

1. Building up of soil fertility through organic manures, inorganic fertilizers and micro-nutrients.
2. Building up of soil fertility through phosphate manuring of legumes.
3. Building up of soil fertility by manuring crops in various rotations.

(ii) *Agronomic experiments*

1. Response to manures and fertilizers.
2. Cultural experiments.
3. Varietal trials.
4. Irrigation experiments.
5. Weed control experiments.

(iii) Vegetable and commercial crops

1. Response to manures and fertilizers.
2. Cultural experiments.
3. Varietal trials.
4. Irrigation experiments.

(iv) Agrostology

1. Flat carrying capacity of pasture crops.
2. Ley farming experiments.
3. Manurial-cum-cutting trials.

(v) Schemes

1. Oil seed scheme (I.C.O.C.)
2. Co-ordinated wheat rust control scheme—Agronomic experiments.
3. T.C.M. fertilizer trials.
4. Grass scheme (I.C.A.R.)
5. Intensive cultivation scheme.
6. Key village scheme.

(vi) Experiments at B.S.S., Pusa

1. Permanent manurial and rotation experiments.
2. New manurial experiments.

(vii) Cattle breeding and management—Sahiwal herd.

1. Line breeding and selection for improvement in milk yield.
2. Feeding of stock on balanced ration for growth, early maturity, and high milk yield.

AGRICULTURAL RESEARCH SUB-STATION, KARNAL

The total area of the Sub-station is 180.12 acres.

The main activities of the sub-station were to (i) carry out large scale field experiments on different aspects of agronomic research, (ii) multiply and distribute seeds of improved strains of field crops and (iii) render assistance to the different Divisions of the Institute in carrying out their field experiments.

I. RESPONSE OF CROPS TO SEASON

The total rainfall from 1st June, 1954 to 31st May, 1955 amounted to 28.34 inches as against 36.18 and 32.13 inches recorded during the corresponding periods of 1953-54 and 1952-53 respectively. The rainfall was slightly above normal which is 25.89 inches.

Due to droughty conditions in the latter part of August coupled with inadequate supply of irrigation and subsequent rains accompanied by high wind in September, adversely affected the maize and cotton crops.

Frost in December and January severely damaged the 'Uptodate' variety of potato and other crops to a mild extent. The *rabi* crops in general suffered from drought during the months of February and March. A hailstorm of severe intensity damaged the tobacco, *bhindi*, maize, onion, berseem for seed and maize and cowpeas fodder crops in April, 1955.

The yields of the principal crops grown on the farm are given below :—

Crop	Area (acre)	Yield per acre (Md.)	Remarks
<i>Grain :</i>			
Paddy	36.82	27.5	
Maize	19.09	7.4	The crop lodged due to rain and high wind.
Cowpea	5.50	8.3	
Cotton	5.95	10.6	
Wheat	75.37	20.8	
Barley	4.03	15.9	
Gram	11.27	17.4	
Pea	5.95	15.7	
Potato	3.34	170.5	
<i>Fodder :</i>			
Jowar	8.31	202.8	
Cowpea	5.80	151.5	
Maize and cowpea	2.50	281.6	
Jowar and cowpea	3.90	194.9	
Berseem	4.00	482.8	One acre of berseem in block No. 5 was very poor due to inadequate irrigation supply.

II. RESEARCH PROJECTS

1. Manurial experiments

(i) *Paddy-wheat manurial experiment.*—The experiment was started in 1951. The manurial treatments consisted of 0, 30 and 60 lb. N, 0, 60 and 120 lb. P O₅ and 0 and 80 lb. K₂O per acre. In the case of paddy, the whole plot was manured while in wheat half of the plot was manured and the other half left unmanured. Both N and P₂O₅ produced significant responses in paddy. The doses 60 lb., and 30 lb. and 0 lb. N gave the yields of

29.21, 26.57 and 25.05 maunds while 120 lb., 60 lb. and 0 lb. P_2O_5 produced 28.26, 27.66 and 24.9 maunds per acre respectively. The interaction NP was also significant. The effects of K_2O and other interactions were not significant. Wheat responded to N only, 60 lb., 30 lb. and 0 lb. produced 16.50, 13.98 and 12.36 maunds per acre respectively.

(ii) *Green manuring of paddy in conjunction with fertilizers.*—*Dhaincha* was used as green manure crop with and without 60 lb. P_2O_5 . Nitrogen as ammonium sulphate at 20 and 40 lb. per acre was applied to paddy sown after green manure. Green manuring (37.83 md./acre) was significantly superior to no green manure (17.64 md./acre). Phosphate did not show any significant effect. Also extra application of 40 lb. and 20 lb. N to green manure treatment did not produce any significant response over green manuring alone. Among the 'no green manure' treatments 40 lb. N (31.21 md./acre) and 20 lb. N (29.35 md./acre) were at par between themselves and significantly superior to control (22.34 md./acre).

(iii) *Paddy nursery manurial experiment.*—The experiment was started in 1952. Response of paddy to nursery manuring at 0, 1,000 and 2,000 maunds of F.Y.M. per acre was not significant. In case of field manuring, 40 lb. N as ammonium sulphate produced the highest yield (42.61 md./acre) and was at par with 20 lb. N as ammonium sulphate (38.34 md./acre) and 40 lb. N as F.Y.M. (37.12 md./acre) but was significantly superior to 20 lb. N as F.Y.M. (36.83 md./acre) and 'no manure' (32.30 md./acre).

(iv) *Fertilizer value of ammonium chloride and ammonium sulphate nitrate.*—This is the second year of the experiment. Three forms of nitrogenous fertilizers *viz.*, ammonium sulphate nitrate, ammonium chloride and ammonium sulphate at 20 and 40 lb. N were applied to paddy in *kharif* and wheat in *rabi* in two different plots. In case of both paddy and wheat, all the manurial treatments were significantly superior to the control. However, the fertilizer treatments in paddy were at par among themselves but with wheat, ammonium chloride (21.54 md./acre) and ammonium sulphate nitrate (21.93 md./acre), at 40 lb. N were significantly superior to ammonium sulphate nitrate at 20 lb. N (18.00 md./acre).

Experiments conducted under T.C.M. project.

(v) *Levels and types of nitrogen and levels of phosphate on non-acid soils.*—Three forms of nitrogen, *viz.*, ammonium sulphate, ammonium nitrate and urea at three levels of nitrogen and three levels of phosphate at 0, 20 and 40 lb. respectively along with three extra combinations 60 lb. N plus 40 lb. P_2O_5 , 40 lb. N plus 80 lb. P_2O_5 and 60 lb. N plus 80 lb. P_2O_5 were included in the experiments with paddy in *kharif* and wheat in *rabi* in separate plots. None of the main effects, interactions and extra combinations in the case of paddy was significant.

In case of wheat, 40 lb. N (26.93 md./acre) gave significantly higher yield than 20 lb. N (22.72 md./acre) which in turn was significantly superior to 'no nitrogen' (16.68 md./acre). Among the forms, ammonium sulphate (28.56 md./acre) proved significantly better than both urea (23.45 md./acre) and ammonium nitrate (22.46 md./acre). Rest of the effects and interactions were not significant.

(vi) *Varieties and fertilizers.*—Paddy N.P. 97 and N.P. 130, medium-fine varieties, were compared with local coarse Jhona variety. Ammonium sulphate and superphosphate treatments consisted of 0, 20 and 40 lb. N and P_2O_5 respectively. N.P. 130 (30.38 md./acre)

proved significantly superior to both N. P. 97 (22.73 md./acre) and Jhona (22.62 md./acre). Also 40 lb. N (28.30 md./acre) was significantly superior to 20 lb. N (26.57 md./acre), which in turn was significantly superior to 0 lb. N (20.85 md./acre). Phosphate effects and interactions were not significant. In case of wheat N.P. 718 (25.24 md./acre) was significantly superior to both N.P. 710 (21.85 md./acre) and local 20.23 md./acre). Among the nitrogen treatments, 40 lb. N (26.32 md./acre) proved significantly superior to 20 lb. N (22.50 md./acre), which in turn was significantly superior to 0 lb. N (18.50 md./acre). Interaction NP was significant. Phosphate effects and other treatments were not significant.

(vii) *Effect of artificial fertilizers in conjunction with organic manure.*—F.Y.M. was applied to paddy at 0, 10 and 20 cartloads per acre. Ammonium sulphate and superphosphate treatments consisted of 0, 20 and 40 lb. N and P_2O_5 respectively. Although the main effects were not significant, higher levels of N, P and F.Y.M. produced greater yields than the lower ones. All the interactions were not significant.

With regard to wheat, 40 lb. N (33.66 md./acre) was significantly superior to 20 lb. N (31.60 md./acre) which in turn was significantly superior to 0 lb. N (27.13 md./acre). Also 20 cartloads of F.Y.M. (32.97 md./acre) produced significantly higher yields than 10 cartloads of F.Y.M. (31.82 md./acre) and this in turn proved to be significantly superior to no F.Y.M. (27.60 md./acre). Phosphate effects were not significant. All the interactions were significant.

(viii) *Time of application of fertilizers.*—There were no significant differences in the yield of paddy when 30 lb. N dose was applied in a single application (i) before transplanting, (ii) at transplanting, (iii) at tillering and (iv) a week before flowering. Between ammonium sulphate and urea, the former (45.96 md./acre) was significantly superior to the latter (43.71 md./acre) and both were significantly superior to the control (41.34 md./acre). Application of ammonium sulphate in two doses of 15 lb. N each, one before transplanting and the other at tillering, produced the highest yield (50.26 md./acre). Superphosphate at 20 lb. P_2O_5 was applied as a basal dose to all the treatments.

In wheat the treatments consisted of three types of nitrogen fertilizers *viz.* ammonium sulphate, ammonium nitrate and urea which were applied on the basis of 20 lb. N either at the time of sowing or at first irrigation. The treatment effects were not significant.

(ix) *Placement of fertilizers.*—In case of paddy, the treatments consisted of two types of phosphate *viz.*, superphosphate and ammonium phosphate and two levels 20, 40 lb. P_2O_5 with four methods of application, namely (i) broadcasting at puddling, (ii) drilling at puddling (iii) dipping the seedling in mud slush mixed with fertilizer at transplanting and (iv) pallets applied a fortnight after transplanting. Nitrogen was equalised by ammonium sulphate to make up 30 lb. N. The differences in the yields due to treatments were not significant and were also not superior to the control (no phosphate).

In wheat also the three forms *viz.*, superphosphate, nitrophos (20:20) and ammonium phosphate (10:48) at two levels of 15 and 30 lb. P_2O_5 as well as two methods of application (broadcast, placement at 2½ inches below seeds) did not differ significantly among themselves. However, 15 lb. (29.50 md./acre) and 30 lb. (28.53 md./acre) P_2O_5 doses were significantly superior to 'no phosphate' treatment (22.79 md./acre).

(x) *Residual value of phosphate*.—The treatments consisted of superphosphate at 0, 10, 20 and 40 lb. P with a basal dressing of 20 lb. N. The differences in yield of paddy due to these treatments were not significant.

(xi) *Minor elements and potash*.—Minor elements, *viz.*, magnesium sulphate, manganese sulphate, ferrous sulphate, zinc sulphate, copper sulphate, borax and sodium molybdate as well as potash were applied to the preceding crop of wheat and their residual effects were studied on maize. 40 lb. N as ammonium sulphate was applied to maize as basal dose. None of the main effects or interactions were found to be significant.

(xii) *N P K experiment*.—Ammonium sulphate, superphosphate and sulphate of potash were applied to paddy at 0, 20 and 40 lb. each of N , P_5O_2 and K_2O respectively. Only N and both were significantly superior to 0 lb. N. (27.50 md./acre). The interaction PK was and both were significantly superior to 0 lb. N. (27.50 md. acre). The interaction PK was also significant.

(xiii) *Soaking of paddy seedlings in nutrient solutions*.—Paddy seedlings dipped in 2.5% solutions of ammonium sulphate, ammonium nitrate, urea, and 5% solutions of superphosphate and ammonium phosphate as well as 2.5% of ammonium sulphate plus 5% solution of superphosphate, and 50% F.Y.M. soil emulsion did not produce significantly higher yields than 'no manure'. This experiment is being run in collaboration with the Chemistry Division.

2. Varietal trials

(i) *Jowar varietal trial*.—J.C. 20 (291.6 md./acre) and J.C. 21 (274.4 md./acre) from the Punjab, C. 10-2 (270.4 md./acre) from Bombay and local *purbi* (260.8 md./acre) produced significantly higher yields of fodder than the varieties J. C. 100, J. C. 263, Nandyal and Sundhia.

(ii) *Wheat varietal trial*.—Wheat varieties N.P. 718, N.P. 792, N.P. 797, N.P. 798, N.P. 799 and C. 591 were tested for their yield both under irrigated and *barani* conditions. The results indicated that C. 591 produced the highest yields both under irrigated (31.77 md./acre) and *barani* (33.28 md./acre) conditions. Among the N.P. varieties, N.P. 718 (irrigated—24.4 md./acre, *barani*—25.42 md./acre) was significantly superior to the remaining varieties both under irrigated and *barani* conditions.

(iii) *Linseed varietal trial*.—Seven N.P. (R.R.) varieties of linseed, *viz.*, 9, 37, 38, 45, 431, 439, 440 and K.2 were included in the trial. The varietal differences were not significant. The highest yield was, however, produced by N.P. (R. R.) 439 (15.52 md./acre).

(iv) *Early and mid-early paddy varietal trial*.—Ten varieties of paddy for test consisted of N.P. 97, N.P. 125, 130, Jhona 349, T. 21, CH. 2, CH. 41, CH. 42, CH. 43 and CH. 45. The differences in yield of varieties were not significant.

(v) *Late paddy varietal trial*.—Among the eight varieties included in the trial, varieties N.P. 137, Basmati 370, CH. 63 and CH. 47 were at par with each other, but N.P. 137 and Basmati 370 were significantly superior to varieties CH. 54, Palman 246, T. 9 and T. 88.

3. Cultural experiments

(i) *Tillage of wheat in conjunction with manuring with F.Y.M. and ammonium sulphate.*—The cultural treatments *viz.*, 'tractor ploughing' (22.88 md./acre), 'Victory-cum-country ploughing' (22.32 md./acre) and 'country ploughing' (21.64 md./acre) were not significant. Among the manurial treatments, ammonium sulphate at 60 lb. N (25.49 md./acre) and ammonium sulphate plus F.Y.M. each at 30 lb. N (25.31 md./acre) were significantly superior to F.Y.M. at 60 lb. N (21.42 md./acre) which in turn gave significantly higher yield than the control (16.9 md./acre). None of the interactions was significant.

(ii) *Tillage of wheat in conjunction with green manure and fertilizers.*—The whole area was green manured with sunn-hemp. The yields of wheat, although in favour of cultural treatment 'Victory-cum-country ploughing' (17.51 md./acre), were not significantly superior to 'tractor ploughing' (14.24 md./acre). Among the fertilizer treatments, only 60 lb. N as ammonium sulphate (19.80 md./acre) was significantly superior to control (11.70 md./acre). P, K and interactions were not significant.

(iii) *Paddy cultural experiment.*—Among the three sowing practices of paddy, none of the treatments, namely transplanting at 10 sr./acre (27.11 md./acre), drilling at 20 sr./acre (26.66 md./acre) and broadcasting at 40 sr./acre (25.61 md./acre) proved significantly superior to each other.

(iv) *Cropping of paddy after paddy in the same season.*—The experiment which was started in *kharif*, 1951 ran for three years. In the first year, the first crop N.P. 97 was transplanted on 2-7-1951 and gave an yield of 41.68 maunds per acre. The succeeding crop transplanted on 20th October, 1951 failed to produce grains due to unfavourable cold weather. In the year 1952, the first crop of N.P. 97 was transplanted earlier *i.e.*, on 14th May, 1952 and gave an yield of 22.30 maunds per acre. The second crop failed completely for the same reason as in the first year. In 1953, early varieties *viz.*, CH. 10, CH. 45, B. 76—116, Kolaba, Sathika and Sona obtained from Sabour and Cuttack for this purpose were sown along with N.P. 97 on 15th March and 1st April in two sets. However, all of these varieties failed to form seeds due to hot and dry weather prevailing during the growing season. The yields obtained from the second crop were also meagre. Thus there seems to be a short period for the optimum growth of paddy under Karnal conditions and therefore, two crops of paddy could not be adjusted within this period.

4. Cultivators' holdings

Long term experiments with three 6-acre cultivators' holdings were in progress to study how far they are self-sufficient in providing the requirements of five human beings and seven cattle.

III. SEED SUPPLY

The following quantities of seeds of improved varieties of crops were distributed during the year under report:—

Wheat	Paddy	Sugarcane setts	Maize	Cowpea	Gram	Berseem	Miscellaneous crops
md.	md.	md.	md.	md.	md.	md.	md.
667.81	180.52	244.13	15.55	33.08	17.46	9.72	1.10

IV. PROGRAMME OF WORK FOR THE YEAR 1955-56

1. *Fertility experiments.*

(a) Fertilization of paddy, wheat and vegetable crops.

2. *Agronomic investigations.*

(a) 6-acre cultivators' holdings.

(b) Varietal trials.

(c) Cultural experiments.

3. *Seed multiplication and distribution.*

2. REPORT OF THE DIVISION OF BOTANY

(Including Botanical Sub-Station, Pusa)

(Dr. S. M. Sikka)

The research work of the Division, aimed at evolving superior varieties of crops plants and gathering fundamental information on botanical problems relating to crop plants, continued under its five sections, *viz.*, Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, Plant Introduction and Systematic Botany, and Horticulture. Further progress was made in breeding varieties of wheat resistant to rusts and smuts under the Co-ordinated Wheat Rust Control Scheme. Other activities included work on research schemes financed by the Indian Council of Agricultural Research and other bodies. These schemes related to the exploitation of hybrid vigour in maize, breeding of some pasture grasses and legumes, study of diseases caused by the deficiency of micro-nutrient elements and plant physiological and cytogenetical studies on colchicine-induced polyploids of some oilseed plants. Two new research schemes, one dealing with the improvement of chilli and the other with that of some essential oil bearing plants like coriander, *somf*, *ajwain*, etc., were sanctioned with effect from the 1st April, 1955. Also from the same date, the charge of the Central Vegetable Breeding Station at Nagar in Kulu Valley was passed on to this Division.

As in previous years, collaborative work, mainly involving exchange and evaluation of plant material and scientific information, was done with the State Departments of Agriculture and individuals and institutions in India and abroad. A considerable volume of advisory work was attended to. Distribution of seeds of improved varieties of field and vegetable crops was done on a large scale. An exhibition depicting the activities and achievements of this Division in the course of its work during the past 50 years was put up at the time of the Golden Jubilee celebrations of the Institute in April, 1955.

The results obtained in the main lines of work in progress during the year 1954-55 are given below.

PLANT BREEDING AND GENETICS

1. Improvement of Indian wheats

Breeding disease resistant wheat varieties.—This work is being done under the Co-ordinated Wheat Rust Control Scheme which is being operated by this Institute at Delhi and at its four sub-stations at Pusa, Simla, Indore and Wellington (South India). The object is to breed varieties resistant to the several physiologic races of the three wheat rusts and to the smuts. In the recent work, emphasis has also been laid on the breeding of varieties suited to *barani* conditions and to different levels of fertility as also on breeding for resistance to lodging and to the bunt diseases. To this end, extensive collections of indigenous and foreign varieties are being maintained and evaluated at these stations and the suitable among them are being used in a comprehensive hybridisation programme, involving single, double, multiple and back-crosses. The aim is to incorporate into single varieties disease resistance from diverse parental sources, the latter including some of the related species of wheat. The work at Delhi, Pusa and Simla mainly aims at the improvement of bread wheat (*Triticum aestivum*), grown in the plains and hills of northern India and that at Indore and Wellington, of hard wheat (*T. durum*) and khapli wheat (*T. dicoccum*) respectively.

A number of hybrid progenies involving some leading wheat varieties, *viz.*, N.P. 710, N.P. 718 and Pb.C. 591 at Delhi, N.P. 770, N.P. 809, Ridley and Simla Local at Simla, N.P. 737, N.P. 755, N.P. 758 and N.P. 761 at Pusa and Malvi Local, Baxi Local, Kathia 19-3 and many others at Indore, and rust resistant indigenous and exotic varieties were under study. The donors of rust resistance have been: N.P. 789, N.P. 790, E. 581, E. 1913, E. 1951, E. 931 and E. 2025 for black rust, E. 952, E. 957 and E. 928 for brown rust and E. 671 for yellow rust. Progenies of certain double crosses, made for obtaining in improved strains resistance simultaneously to more than one rust, were also under study. Three of the newly evolved strains, N.P. 797, N.P. 798, and N.P. 799, are highly rust and smut resistant and are early-maturing and high yielding. But their ears are long-tipped. As fully-bearded varieties are preferred by cultivators, these wheats have been suitably crossed to breed the beard character into them, Pb. C. 273 is one of the varieties which are being utilised in breeding for resistance to lodging.

Interspecific crosses—*aestivum* X *durum*, *aestivum* X *dicoccum*, and *durum* X *dicoccum*, have also been made for utilisation in the breeding. The varieties involved in these crosses were: *T. aestivum*—N.P. 710, N.P. 718, N.P. 786 and E. 572 (Ridley); *T. durum*—E. 931 (Gaza), E. 2025 (Aravian wheat), E. 2158 (Egyptian wheat); and *T. dicoccum*—I.C. 1057, an indigenous sort.

Rust resistance tests.—This work is being done in collaboration with the Division of Mycology and Plant Pathology.

At Delhi 367 indigenous and exotic varieties, 652 such varieties at Pusa and 73 at Simla were tested in the field at the adult stage of the plant for resistance to the several races of the three rusts; similar work on 273 varieties at Indore was confined to testing for resistance to black rust only. Some of this material tested was remarkable for its resistance to all the races of one or, simultaneously, two rusts; E. 2143 (Tremez Molle from the U.S.A.) was free from all the three rusts at Delhi. At Indore, all the indigenous varieties of *durum*, both local and improved, were susceptible to black rust, but some foreign *durums* were observed to be free from it.

Seedling tests on some foreign wheats showed that E. 871 (a Timstein derivative), E. 1913 and E. 1951 (Kenya derivatives) and E. 2025 (an Arabian *durum*) showed semi-resistant reaction to the newly-isolated Race 122 of black rust—to which almost all the indigenous and foreign varieties in the collection, including the several improved wheats, were observed to be susceptible. Some of the recently made rod-row selections were found to be resistant to several races of black rust; two such promising selections, H.D. (52)-1 and H.D. (53)-37 showed semi-resistance to the Race 122 mentioned above.

A considerable number of hybrid progenies, *e.g.*, 1,150 families comprising about 18,000 plants at Delhi, 2,059 families at Indore, about 43,000 plants at Simla, were adult-tested against the rusts in the field; selections were made in these progenies on the basis of rust resistance and desirable agronomic characters.

Breeding for resistance to loose smut.—Sixty-six Indian and foreign varieties at Delhi and thirty at Simla were tested for resistance to smut under conditions of artificial infection with the disease. Among those that remained free from smut were: Exotic—E. 957, E. 931, E. 1913, E. 1951, E. 2158; N.P. varieties—N.P. 710, 718, 768, 770, 783, 790, 797, 798, 799, 803, 809 and 815; new rod-row selections—H.D. 52—Nos. 70, 71, 75 and many others.

Breeding for resistance to the hill bunt.—Thirty-one wheat varieties were tested at Simla. While most of the commercial varieties, including the improved ones, and rust resistant strains appeared to be susceptible, N.P. 786 and N.P. 785 were the only strains showing incidence of bunt as low as 7.5 and 11.7 per cent respectively.

Breeding wheats for growing under barani conditions.—The performance of 128 wheat strains, which included 16 new and promising rod-row selections, was critically tested for assessing their suitability for growing under unirrigated conditions. The highest yield (0.58 ozs. per plant) was given by N.P. 773 which came into ear the earliest (99 days); this variety was closely followed by N.P. 715 and N.P. 165. Among the rod-row selections, H.D. (53)-7 gave the best performance.

Yield trials of promising varieties.—Several yield trials were conducted during the year in the different wheat-growing tracts in the hills and plains of the country. In Bihar, the results confirmed the superiority of N.P. 761 and N.P. 758. The newly-evolved rust resistant variety, N.P. 799, also gave an excellent performance. A foreign wheat, E. 871 (a Timstein derivative), yielded at Pusa (Bihar) about 34 per cent more than the standard, N.P. 52. E. 871 is resistant to most of the races of the three rusts both in the seedling and adult stage of the plant; however, its grain quality is not very satisfactory.

The results of the regional trials in the plains have brought out the superiority of N.P. 710 and N.P. 718 and also of the new rust resistant strains, N.P. 797 and N.P. 799. In Madhya Bharat, N.P. 710, N.P. 718 and N.P. 758 were found to be the most suitable; N.P. 710 stood first at Mahagarh and at Charkhari (U.P.). N.P. 758 gave the best yield under *barani* conditions. In Bombay, N.P. 710 did the best at Dabhoi and at Niphad N.P. 758 stood first and N.P. 799, second. In Saurashtra, N.P. 718 did best at Aliabada, N.P. 799 standing second. N.P. 718 was the top yielder at Cuttack (Orissa).

In the hills of Himachal Pradesh, Punjab and Uttar Pradesh, N.P. 809 and the Australian variety, Ridley, gave top yields; N.P. 770 maintained its excellent performance at high altitudes. N.P. 813 is another wheat which has shown promise in the lower hills of Uttar Pradesh. At Wellington (Nilgiri Hills) N.P. 812 and N.P. 813 did best, both in yield and rust resistance.

Seed production and supply.—For sowing during the *rabi* season of 1954-55, the demand from growers for seeds of N.P. wheats totalled 8,000 mds. of which only about 2,000 mds. could be supplied from the Institute's stocks. In addition 1,000 mds. and 200 mds. of seed of N.P. 718 were made available to Rajasihan and Madhya Bharat, respectively, from the produce of this variety grown in Delhi villages. Similarly, the Gwalior Dairies in Madhya Bharat supplied 500 mds. of seed of N.P. 710 to Orissa. The Uttar Pradesh Department of Agriculture produced and distributed about 5,000 mds. of seed of N.P. 710 for further multiplication on Government farms in that State.

World catalogue of genetic stocks.—This item of work is being done in collaboration with the F.A.O. In addition to the information supplied during the previous years, full descriptions of 38 Indian wheat varieties were supplied during the year and similar data were collected in respect of another set of 100 varieties.

Genetical studies.—The mode of inheritance of resistance to individual races, or to mixtures of races, of black rust was studied. In the seedling tests, susceptibility to Race 15C was governed by a single dominant gene, whereas in the case of Race 21 and Race 42, resist-

ance was conditioned by two duplicate genes. The adult-plant reaction to a mixture of races of black rust was determined by a single gene, resistance being dominant. The brown colour of glume and pubescence of glume were each governed by a single dominant gene. Two duplicate genes in one cross and a single dominant gene in three crosses controlled the awned condition of the ears. Grain colour was found to be determined by a single dominant gene in some crosses and by two or three dominant genes in others.

2. *Breeding rust resistant barleys*

Barley is a collateral host of the black and yellow rusts of wheat. Breeding rust resistant varieties in this crop is, therefore, important if the problem of the wheat rusts is to be tackled effectively.

Eight hundred and eighty varieties were tested at Delhi and Indore under natural conditions of rust infection and 506 varieties at Pusa and Simla under artificial infection with mixtures of races of the two rusts. A number of them showed an encouraging degree of freedom from the disease.

In yield tests at Delhi, C. 141—a 6-rowed variety from the Punjab, yielded best, although not significantly more than N.P. 13 and N.P. 22. In trials in Himachal Pradesh, B-70 and Simla Local appeared to be the best yielders. Crosses have been made between some of these leading varieties and rust resistant barleys for breeding superior disease resistant strains.

3. *Breeding for wilt resistance and early maturity in Arhar (Cajanus cajan)*

Sixty-eight families of a cross, N.P. 51 x U.P. 132, bred for wilt resistance and early maturity were sown in a compact family design lay out with 4 replications along with two of the promising N.P. types, N.P. 41 and N.P. (C) 15 and some of the improved types from different States. Under conditions of artificial infection, two of the hybrid cultures were free from infection and 23 cultures were slightly affected (0.1 to 5.0%). N.P. (C) 15 was also free from infection. As regards maturity, the promising provincial types included in the tests took 100-105 days to flower from the date of sowing, the new hybrid derivatives took 112 to 125 days and N.P. 41 and N.P. (C) 15 took 125 to 130 days. Several of the hybrid derivatives also gave 20 to 25% higher yield than the improved provincial types. Two yield trials of promising wilt resistant varieties were conducted, one in a wilt-sick plot and the other in a non-wilt sick plot. The N.P. (C) types gave significantly higher yields than the promising provincial strains in the wilt sick plot, N.P. (C) 15 Pusa giving the highest yield. In the non-wilt sick plot, N.P. (C) types were compared with N.P. 41 and N.P. 80. N.P. (C) 38 gave the highest yield of 1,152 lb. per acre, followed by N.P. (C) 15 Pusa and N.P. (C) 15 W.E. which yielded 1,044 and 1,034 lb. respectively.

Protein content was determined in 24 types. N.P. 24 and N.P. (D) 16 which had 24.1 to 26.0% were the best among the N.P. types, while E.B. 38 (M.P.), F.1 and F.18 (Bombay), which had 22.1 to 24% protein, were the best among the improved provincial strains.

Trials of N.P. wilt resistant *Arhar* types were arranged at 11 centres in 6 States during 1954-55. The results have so far been received from Berhampur (West Bengal) and Kanpur. At Berhampur, all the N.P. wilt resistant varieties out-yielded the local, and also showed a high degree of resistance to wilt. In the observation-row trial conducted at Kanpur, the wilt resistant strains gave a slightly lower yield than some of the locals.

4. Breeding of rust resistant and early maturing strains of Linseed

One hundred and twenty-five progenies from crosses involving Bolley Golden and Afghanistan-2, and comprising F_1 , F_2 and back-cross populations and parents, were sown in a replicated progeny row trial with two replications for estimating their resistance to rust under conditions of artificial infection. A part of the seed of this material was sent to the Mycology Division for testing for rust resistance in the seedling stage. With the help of the Mycology Division, 100 hybrid progenies were artificially inoculated in the field with a mixture of the five physiologic races of linseed rust so far isolated. Of these 89 progenies were resistant to rust, 7 segregated for resistance and susceptibility and the remaining 4 were susceptible. The susceptible progenies presumably succumbed to the fifth physiologic race of the rust which has been recently isolated. One hundred and thirty-four single plant selections were made in the field on the basis of rust resistance, early maturity and good bearing and branching.

Grain weight was recorded in the 134 selections and it was observed that some selections gave 25 to 40% higher grain yield per plant than their respective parents. These single plant selections yielded in some cases more than N.P. (R.R.) 9 which is the best among control lines. Several new crosses have also been made to evolve early maturing, rust and wilt resistant linseed strains suitable for cultivation in Central and Peninsular India.

Yield trials were conducted at Delhi and at 13 centres in other States to assess the performance of new N.P. (R.R.) types in comparison with the best local types. In the trial at Delhi, N.P. (R.R.) 439 gave the highest yield (1,625 lb.), thus repeating its performance during the last season. At Kanpur, N.P. (R.R.) 440 out-yielded the improved types of Uttar Pradesh and the other Pusa types. All the N.P. rust resistant types yielded more than the local strains in a trial conducted at Patna; N.P. (R.R.) 439 topped the list and it was closely followed by N.P. (R.R.) 9, 5 and 440. Similar results have been observed in the trials conducted at Bhubaneswar (Orissa), Gwalior and Karnal (Punjab). Studies on the genetics of rust resistance in linseed are in progress and back-crosses between resistant F_1 and susceptible parent have been made. A study of the genetic variability for several quantitative and qualitative characters has been initiated in 100 indigenous and exotic linseed strains.

5. Sesamum

Thirty-three indigenous and thirty-five exotic types, besides the N.P. strains of *Sesamum orientale* and the related species were grown for maintenance and study. There was a heavy attack of *Macrophomina phaseoli* on the plants 4 to 6 weeks after they were sown. It was noted that all types except N.P. 6, I.C. 1830 (a Punjab type) and E.C. 1015 (from Australia) were badly affected by the fungus. Selections from *S. orientale* x *S. prostratum* also stood the attack very well. Results from yield trial of *orientale-prostratum* selections conducted at Delhi and five other centres in Central and Northern India were inconclusive owing to the damage caused to the plants by rain and diseases.

Seeds of N.P. 6 which had been irradiated with X-rays in 1953 at the National Physical Laboratory were sown during the *kharif* of 1954. The germination was generally poor; the lowest dosages (8 hour treatment) gave 60% germination. The higher dosages were lethal. Only two plants survived from 8-hour treatment and these were seed-sterile. Thus, more experiments have to be undertaken to ascertain the optimum dosage for the induction of economic mutations.

6. *Chilli*

In a yield trial with 7 N.P. varieties and 1 local, N.P. 46 A gave the highest yield of 26.2 mds. per acre. The local strain yielded 14.9 mds., while N.P. 41 and N.P. Hyb. 5-1-5 yielded 20.4 mds. each. A co-ordinated scheme for the improvement of chilli, sponsored by the Indian Council of Agricultural Research, was started from 1st April, 1955, the objective being to breed varieties resistant to diseases. For this work, 87 collections have been made from within the country and 6 strains have been obtained from Turkey.

7. *Potato*

Darjeeling Red Round gave the highest yield in the yield trial conducted to compare the performance of Hybrids 209, 2885, 45 and 208 with the commercial varieties. Hyb. 209 gave the next best yield.

8. *Cotton*

Fifteen Indo-American varieties were compared with reference to yield in a randomized blocks lay-out with four replications. The variety 320 F (Punjab) gave a calculated yield 25.8 mds. of Kapas per acre and this was followed by M and 216F-14. This is the fourth year of the trial and the results have largely confirmed the previous findings.

Sixteen F_1 hybrids, involving inbred lines of Indo-American varieties of cotton, and their corresponding parents were tested in randomized blocks with four replications for the study of the manifestation of hybrid vigour in respect of plant height, number of internodes, number of good bolls and bad bolls per plant, size of boll, locks per boll, lint index, seed index, ginning percentage, halo length, etc. The F_1 of the cross (Co. 2 x 216F) showed higher value as compared to the parents in all the characters studied.

9. *Tobacco*

The indigenous and exotic collections of *Nicotiana tabacum* and *N. rustica* and seventeen *Nicotiana* species were grown for maintenance. Seeds of two promising *hookah* types (*Nicotiana rustica*), N.P. 219 and N.P. 220, were multiplied for distribution.

10. *Hybrid Maize*

This work is being done under a scheme financed by the Indian Council of Agricultural Research.

Maintenance, collection and testing of open pollinated varieties.—Forty-three Indian and 24 exotic varieties were maintained. In addition, 29 new collections from Indian and 70 varieties from Central and South America were added to the collection and multiplied. These new varieties were planted in yield trials.

Fifty-two Indian and foreign varieties were tested in two experiments at Delhi. The exotic varieties, Jellicose and Amarillo de Cuba, gave top performance. Among the Indian varieties the high yielding ones were Piarka Local, Jawapur white, Phugwara Local and Jullundur Local. These varieties matured at the same time as the control, K.T. 41.

Seventy varieties from Central and South America, received through the courtesy of the Rockefeller Foundation, were put in observation plots at Delhi and at 12 other locations in India. The varieties that appeared to be best adapted and high yielding were G. 788w., Durango, Rocamex H-503, Popaloapan, G-733, Cornelli 31 and H.m.d. 4624. However, these varieties were later maturing than K.T. 41.

Production, maintenance and introduction of inbred lines:

Indian inbreds.—The total number of short term inbreds grown from S_1 to S_4 generations was 720. About 310 desirable inbreds were selected in the field on the basis of plant and ear characters and top cross yield trials. Fourteen inbreds showing high combining ability will be put in single crosses. The other selected inbreds will be further inbred and tested in top crosses. Inbreeding was newly carried out in promising Indian open pollinated varieties, K. T. 41, Basi, Jullundur Local, Jathua-D., and certain exotic south American varieties. One hundred and seventy-eight inbreds in S_5 and later generations were grown. On the basis of the results of top-cross yield trials low combining inbreds were discarded.

Exotic inbreds.—Thirty-two exotic inbreds, that are the parents of promising U.S. double crosses, N.C. 27, Dixie 18, Dixie 11, Texas 26, U.S. 13, etc., were grown and multiplied. Fourteen new inbreds were received from the U.S.A. Moreover, 52 flint and dent inbreds were received from Central and South America. These inbreds will be used in the production of single crosses among themselves and with Indian flint inbreds.

Testing of inbreds in top crosses and single crosses:

Top cross.—Three trials were conducted with top crosses, and 108 inbreds, mainly in the S_1 and S_2 generations, were thus tested for general combining ability. In all, 24 cultures significantly out-yielded K.T. 41; 11 cultures yielded more than N.C. 27, a top performing U. S. hybrid, but the differences were not statistically significant.

Single crosses.—Three trials were conducted with single crosses produced at this Division and 108 hybrids were tested for specific combining ability of inbred lines. Fifty-five hybrids significantly out-yielded K.T. 41 and 15 single crosses yielded more than N.C. 27, but the differences were not statistically significant.

Trials with the U.S. Maize hybrids.—In a trial under intensive cultivation, where the plot size was $1/2$ acre, N.C. 27 yielded 56 mds. 16 seers grain per acre while K.T. 41 gave 46 mds. 16 seers per acre.

Trials with 5 top performing U.S. maize hybrids were conducted at 8 locations and results are so far available from 3 locations. Texas 26 and N.C. 27 were the first two hybrids with regard to yield. The yield of the best hybrid expressed as the percentage of the best local at different locations ranged from 97% at Gurdaspur (Punjab) for N.C. 27 to 150% at New Delhi for Texas 26.

On an average, the U.S. hybrids matured 10 to 15 days later than the locals.

Ten pound seed of Texas 26 has been produced at this Division during 1954-55. The seeds are under trial at three locations and will be tested against the best locals and the imported Texas 26.

11. *Jowar and Bajra*

Work on *jowar* and *bajra* is directed towards the production of improved types suitable for north India in general and Delhi State in particular.

A replicated yield trial of 5 promising varieties of *bajra*, viz., T. 55, I.C. 1518, I.C. 1476, I.C. 1519 and I.C. 1718, was conducted using the Delhi Local as control. Owing to unfavourable weather conditions, the data obtained proved inconclusive. Several crosses have been made in *jowar* and *bajra* with a view to combine characters like earliness, height and high yielding ability. Crosses between varieties of *jowar* and Sudan grass have been made to evolve

good drought-resistant fodder types. An extensive collection is being made of indigenous and exotic varieties of *jowar* and *bajra* with a view to combine characters like earliness, height and high yielding ability. A noteworthy introduction is the male sterile *jowar* received from the United States. It is proposed to use it in hybrid vigour studies.

12. Tomato

The autumn-winter crop of tomato is usually liable to considerable damage by virus infection. Hence observations were recorded on the incidence of virus diseases in a replicated yield trial of promising varieties. The following results were obtained.

Variety	Percentage of virus-infected plants
Improved Meeruti	9.06
Sioux	24.37
Prosperity	19.06
<i>Sioux x Meeruti Selections :</i>	
Hybrid 10	18.44
„ 11	21.25
„ 12	16.87
„ 13	15.62
<i>Meeruti x Red Cloud :</i>	
Hybrid 14	12.81

In the previous years also, “Improved Meeruti” showed the highest stand of healthy plants. One of the hybrids derived from crosses with this variety, No. 14, was also comparatively less infected with viruses.

The varietal hybrids between “Sioux” and “Meeruti” again showed increase in yield over the superior parents. As in the previous year, the increase was high (67.33%) when “Meeruti” was used as female parent. In the reciprocal hybrid the increase was 27%. Crossing and selection work is in progress for developing suitable male sterile lines in “Sioux” and “Meeruti”. Crosses have also been made between a closed anther mutant in the variety, “John Baer”, obtained from the United States, and selected commercial varieties.

Observations on the keeping quality of ripe tomato fruits during hot, dry summer months showed that “Improved Meeruti” is the best keeper, the loss being only 12% over a period of 40 days. As observed during previous years, rotting was high in the variety “Sioux”. Thus, “Improved Meeruti” is more suitable for being marketed at distant places.

13. Bhindi

Breeding for resistance to yellow-vein mosaic.—Suitable selections were made of mosaic-free plants in the F_1 and back-cross progeny of crosses involving “Pusa Makhmali” and the mosaic tolerant varieties, I.C. 1524, I.C. 1532 and I.C. 1542. The selections were made mainly on a combination of characters such as earliness, 5-edged condition and dark green colour of the fruit and resistance to yellow-vein mosaic.

Hybrid vigour.—The hybrid vigour experiment was again repeated. Heterosis was observed in respect of fruit yield in several combinations, the percentage increase over the better parent being as high as 59.3 in the cross "Pusa Makhmali" x I.C. 1510 (a mosaic tolerant, 8-edged variety). Heterosis had also been noticed in this cross during the last season's experiment. In some combinations negative heterosis was noticed. Reciprocal differences in the vigour of the hybrids were noticed in some combinations. It appears from the result that combination of 5-edged with 8-edged varieties showed more vigour than crosses within either the 5-edged or the 8-edged group.

14. Improvement of Brinjal

Two varieties, "Pusa Purple Long" and "Pusa Purple Round", were finally selected and multiplied for distribution. The varietal collection comprising 54 varieties was grown for maintenance and study.

15. Breeding of some pasture grasses and legumes

Work on this scheme, financed by the Indian Council of Agricultural Research, made further progress this year. One hundred and thirty-two strains of grasses and forty strains of legumes were planted in the trial plots. Two strains of *Pennisetum ciliare* (I.C. 2136 and E.C. 5603), one strain of Lucerne (I.C. 3143) and one strain of *Dichanthium annulatum* (I.C. 2131) gave the best performance. Local strains of *Cenchrus* grew very well under rainfed conditions. *Brachiaria brizantha* and *Urochloa mosambicensis* remained green throughout the year under wholly rainfed conditions. A study of the self- and cross-compatibility relationship among the various grass species was continued. Selfing did not lead to a reduction in seed setting in comparison with open pollination in *Cenchrus*, *Pennisetum* and *Pichanthium*. The selfed progenies are under study.

CYTOLOGY AND CYTOGENETICS

16. Crop improvement through colchicine-induced autopolyploidy

Brassica.—Three *elite* isolates of autoteraploid *toria* were raised in three different isolated plots and the populations were studied with reference to seed fertility. Selections were made according to the Mass Pedigree system. A comparison of the seed fertility level of the *elite* population "A" during the year 1954-55 with that of *elite* "A" during 1953-54 showed that there was an increase in the frequency of high-fertile classes and decrease in the low-fertile classes, the trend which has been noticed during the past three years thus having been maintained.

Yield trials of tetraploid *toria* initiated last year were continued on a large scale. During the present year, when four yield trials were conducted—three at Delhi and one at Pusa—the tetraploids gave for the first time an increased yield over the diploids. The oil content in the tetraploid has been already estimated to be higher than that in the diploid and hence the oil yield per acre of the tetraploid is likely to be quite high in comparison to that of diploid varieties now grown. At Delhi, the tetraploids gave a calculated yield of about 1,200 lbs. per acre as against 1,000 lbs. per acre of the of the diploi. In the yield trial at the Botanical Substation, Pusa, the tetraploids yielded 52 lb. more per acre than the diploids.

At the time when colchicine treatment was first done in *toria*, the material for treatment had been chosen at random. Hence five years ago, a new set of colchicine treatments was started and six different types of *toria*, chosen for their yield characters, were treated. These new tetraploids are in the C_6 generation and even at the early stages, it was noticed that they were much better with reference to seed setting than the old material. During the year under report, some of the unselected material among the new tetraploids compared favourably with the *elite* isolates of the older series. Selections have been made in the new material. A comparative study of pollen tube growth and fertilisation in diploids, high-fertile tetraploids and low-fertile tetraploids of *toria* indicated that the high seed sterility in some tetraploid lines is due to pre-fertilization abnormalities. Preliminary observations suggest that the growth of the pollen tube down the style is normal. Further studies are in progress.

Linseed.—Selection for high fertility in autotetraploids of N.P. (R.R.) 5 and 63 was continued. This year the frequency of high-fertile tetraploids increased only in N.P. (R. R.) 63 while such an increase was noticeable in both varieties during the last year. The C_3 generation of the later-produced tetraploid of N.P. 21, N.P. (R.R.) 45, 122, 272 and 423, was studied and data have been recorded on their yield characters. Embryological studies in tetraploid lines confirmed the previous finding that failure of fertilisation is chiefly responsible for the sterility of the tetraploids. Associated with the failure of fertilisation, there was always also a failure of the fusion of polar nuclei.

Fodder crops.—Tetraploid plants of berseem (*Trifolium alexandrinum*) and *senji* (*Melilotus alba*) were produced by colchicine treatment of seedlings. The most effective methods of treatment were (a) epicotyl treatment in 0.2% colchicine for 2 hours at 30 °C. and (b) seedling treatment in 0.05% colchicine for 8 hours at room temperature. Seed setting was low in the tetraploids, the average number of seeds per inflorescence being 2 to 5 in comparison with 33 in the diploids. Seeds of tetraploid plants will be multiplied in the coming year.

17. Monosome genetics in *Triticum aestivum*

Studies on the location of genes conferring resistance to races of black, brown and yellow rusts through the use of monosomes were commenced during the year. The following crosses were made in the monosomes isolated from the 21 different monosome lines of the variety, Chinese Spring, received through the kind courtesy of Dr. E. R. Sears of the United States.

Monosomes	<i>aestivum</i> variety used in the cross	Purpose
I to XXI	Cometa Klein (E. 671)	Location of genes giving resistance to yellow rust
I to XI, XIII to XVIII and XXI	Rio Negro (E. 951)	Brown rust
I to II	Kenya (E. 1447)	Black rust

Monosome lines have been grown at the Wheat Breeding Sub-station, Simla, during summer, 1955, to complete the crossing programme.

18. Interspecific and Intergeneric hybridization in *Triticum*

Amphidiploids between *T. dicoccum* and *T. monococcum*, *T. timopheevi* and *T. monococcum* and *T. timopheevi* and *T. durum*; named *dimococcum*, *timococcum* and *sovieticum* respectively, have been synthesised and are being crossed to *aestivum* and *durum* varieties. The F_1 of *dimococcum* $\times$ *durum* (Eg. 8626) has 35 chromosomes and showed 1.97 trivalents, 11.64 bivalents and 5.54 univalents per cell at meiosis. In the F_2 of this cross, nearly 75% of the plants had $2n = 29$ or 30 chromosomes. Thus there is a tendency to revert to the tetraploid chromosome number level. A similar trend was also noticed in the F_2 of crosses between *dimococcum* and the *durum* varieties, Jaya and Gaza, from which some segregates with tough rachis, long ears, early flowering and resistance to rust have been isolated. The F_1 hybrids of *dimococcum* $\times$ *aestivum* were semi-lethal and this difficulty was overcome by using *durum* as a bridge species in the cross.

19. Interspecific hybridisation involving the cultivated Bhindi (*Abelmoschus esculentus*).

The second generation of the amphidiploid between *A. esculentus* ($2n = 130$) and *A. tuberculatus* ($2n = 58$) was grown in the field, the population consisting of over 1,000 plants. Observations were taken on the incidence and intensity of yellow-vein mosaic virus infection in the population. Only 11 amphidiploid plants appeared to be free from the virus symptoms. They have been selected and selfed for further testing. Back-crosses have been made between the amphidiploid and cultivated varieties since the amphidiploids as such are not suitable for commercial cultivation. Meiosis was studied in the amphidiploid and a range of 3 to 10 quadrivalents per cell was observed at Metaphase I.

Several new inter-specific crosses have been attempted in this genus. Also, the chromosome numbers of *A. pungens* and *A. tetraphyllus* have been recorded for the first time to be $2n = 138$.

20. Cyto taxonomic studies in the genera *Capsicum*, *Lycopersicon* and *Solanum*

A cytogenetical study of evolution of species differences and intra- and inter-generic crossability barriers among 25 species belonging to the genera *Capsicum*, *Lycopersicon* and *Solanum* showed that (a) the species *Solanum torvum* and *S. hispidum* are homozygous for a segmental interchange (b) embryo-endosperm mother plant incompatibility is the cause of failure of seed-set in intra-generic crosses and (c) failure of fertilisation either due to the inhibition of pollen germination or due to slow growth of the pollen tubes leads to the failure of inter-generic crosses. Suitable techniques are being evolved to overcome these crossability barriers.

21. Differentiation of tuber-bearing and non-tuber-bearing species of *Solanum*

Reciprocal crosses between *Solanum melongena* var. Pusa Purple and *S. tuberosum* var. Phulwa failed due to the inhibition of pollen tube growth. The variety Phulwa is characterised by the formation of a mean number of four quadrivalents per cell during metaphase I of meiosis in microsporocyte. The leaf index of Phulwa falls within the *S. andigenum* range. Since this variety probably represents one of the early introductions from Europe, its leaf

index character and ability to tuberise well under the short day conditions of sub-tropical latitudes will further support the views of the late Dr. R. N. Salaman that the early introduction of potato into Europe took place from the tropical Andes region and not from Chile as suggested by Dr. S. M. Bukasov and other Russian workers.

22. Cyto-taxonomical studies in Indian grasses

A detailed study of the chromosome number and meiotic behaviour in different strains of *Heteropogon contortus* and *Chrysopogon montanus* revealed the existence of chromosome races in these species. Diploids, tetraploids and hexaploids ($2n=20, 40$ and 60) were identified in *H. contortus* while diploids and octoploids ($2n=20$ and 80) were found in *C. montanus*. The method of origin of these polyploid races and their ecological and adaptive significance are under study.

23. Karyotype studies in wheat.

The presence of two chromosomal biotypes differing in the number of satellite-bearing chromosomes in the complement was reported last year in khapli (*Triticum dicoccum*). The F_1 of the cross between Biotype 1 (two pairs of satellited chromosomes) and Biotype 2 (one pair of satellited chromosomes) confirmed the previous finding by having only 3 chromosomes with satellities. A detailed karyotype analysis of the parents and F_1 and of meiosis in F suggested that an extra pair of small chromosomes observed in Biotype 2 should have lost the satellited portion. A few quantitative characters were found to be associated with this change in the karyotype.

24. Effects of chemical mutagens on plant chromosomes

A study of the effects of chemical mutagens on chromosomes with a view to develop a suitable method for the induction of mutation in crop plants was undertaken during the year. To start with, nitrogen mustard, di- (2 chloroethyl) methylamine hydrochloride, which is known to be a very potent mutagen and at the same time less toxic to cells, was used in the experiment. The plant material consisted of diploid, tetraploid and hexaploid wheats, maize, pea and broad bean. The concentrations of the chemical tried ranged from 0.0001% to 0.01% and the duration of the treatment ranged from 3 to 60 minutes. Among the different material, wheat was the most sensitive to the treatment and among the treatments, 0.0005% for 5 minutes and 0.0001% for 15 minutes produced the maximum aberrations without at the same time drastically affecting the revival of the roots to normal divisions and growth. In an experiment designed to ascertain the stage of mitosis which is most vulnerable to the action of the chemical, it was found that early prophase and interphase nuclei show the effects of the chemical most. The effects of nitrogen mustard were also studied on the gametic cells of wheat by injecting various concentrations of the chemical into the space between the flag leaf and developing ear at different stages of growth. Similar treatments were found to have different effects in diploid, tetraploid and hexaploid wheats, diploid being affected the most and hexaploid, the least. A high percentage of pollen sterility (70 to 85%) and poor seed setting (2 to 14 seeds per ear instead of 28 to 42) resulted from the treatment. At meiosis numerous chromosome breaks and other abnormalities were observed. Seeds from the treated plants have been grown at the Wheat Breeding Sub-station, Simla, and are being examined for possible mutations.

25. Cytological technique

Replacement of acetic acid with propionic acid in the acetic-alcohol fixative and aceto-carmin stain led to superior fixation and staining in the study of microsporogenesis in many plants with small chromosomes like those belonging to the genera *Solanum*, *Andropogon* and *Heteropogon*. The schedule consists of fixing anthers for 24 hours in a mixture of 3 parts of absolute alcohol and 1 part of propionic acid saturated with ferric acetate and smearing them in a drop of propiono-carmin. The improved results obtained with this schedule may be due to the ability of propionic acid to hold more iron in stable solution and also to dissolve more carmin.

PLANT PHYSIOLOGY

26. Study of drought resistance in wheat

A pot-culture experiment was undertaken with two varieties, N.P. 710 and N.P. 798, the latter having been found consistently superior in yield to N.P. 710 under drought conditions during the last two seasons. During the season under report, N.P. 798 again out-yielded N.P. 710 under intermittent drought which was commenced from the 4th February. The superior yield of N.P. 798 was due to higher 1,000-grain weight. There was little difference in grain number, whereas N.P. 710 had a significantly higher ear number.

It has been repeatedly observed that ear number has the most potent effect on yield under normal water supply, whereas under drought, grain number as well as 1,000-grain weight have a more or less equal effect. An attempt was made during the present season to see if yield was correlated with photosynthetically active foliage during the period of grain setting. Periodical observations on green leaf area and on grain weight in mother shoots, after anthesis, indicated a slower yellowing of foliage and a more rapid increase in grain weight, from about two weeks after anthesis onward, in N.P. 798. This characteristic difference was noticed only under drought. A relation between functional activity of foliage and grain filling, under drought, is thus indicated. It would also appear that the foliage of N.P. 798 is relatively more drought-resistant as it dries up less quickly under deficient water supply.

A replicated field trial was laid out, with and without irrigation, with 8 varieties of wheat, namely, N.P. 798, N.P. 52, N.P. 710, N.P. 718, Afghanistan, Florence x Aurore, Pb. C. 228 and Ridley. Periodical soil-moisture determinations up to a depth of 4 feet and the corresponding data on wilting co-efficient and moisture equivalent indicated an appreciable soil-moisture stress in the first two feet from December onward. Periodic determination of green leaf area of mother shoots, after anthesis, indicated a varietal difference in the rate of yellowing of foliage. The foliage of N.P. 798 dried up most slowly in the unirrigated plot only and thus the distinction between this variety and N.P. 710 was confirmed under field conditions. There also appeared to be a correlation between green leaf area and grain yield in the unirrigated plot, but not under irrigation. Leaf area was perhaps not a limiting factor under sufficient water supply.

27. Physiological analysis of factors concerned with yield.

In a pot experiment with three varieties of wheat, namely, N.P. 710, Pb.C. 228 and Kende, the effect on yield of removal of flag leaf and other leaves after anthesis, was studied. Indirectly these treatments gave an estimate of the contribution of the different

leaves to yield. In Pb.C. 228 and Kendee, the flag leaf contributed as much as the other leaves whereas in N.P. 710 the flag leaf contributed half as much as the other leaves. The contribution of all the leaves to yield was about 33%.

28. Plant hormones

In a pot-culture experiment involving two varieties of wheat, N.P. 710 and Pb. C. 228, two hormones, alphanaphthalene acetic acid (NAA) and betaindolyacetic acid (IAA) at 75 p.p.m., and spraying the hormones at 3 stages, namely, at commencement of tillering, at shooting and on the unfolding of boot leaf, and two levels of nitrogen, sufficient and deficient, it was found that application of NAA at tillering, under sufficient nitrogen supply, increased the yield of Pb. C. 228 significantly, due to increase in 1000-grain weight.

In a replicated field trial, involving 0 and 20 lb. nitrogen per acre and spraying NAA (75 p.p.m.) at three stages namely, at commencement of tillering, at shooting and at boot-leaf, it was found that nitrogen alone increases the yield of wheat, N.P. 710.

In a pot-experiment, involving two wheat, N.P. 710 and Pb. C. 228, soaking of seeds in 0.01 and 1.0 p.p.m. of NAA solutions for 24 hours and exposure of the soaked seeds to a low temperature (about 5°C) for 2 weeks and to room temperature for about 48 hours, prior to sowing, it was found that none of the treatments increased the grain yield. The low temperature, however, decreased tillering and hastened ear emergence.

The effects of a wetting agent, of lanolin and of the wilted condition of the leaves on the response to NAA spray were compared in another experiment under pot-culture. The treatments were : a proprietary product, "Planofix", containing a wetting agent along with NAA, at 3 dilutions to give 25, 50 and 100 p.p.m. NAA, 50 p.p.m. NAA on wilted leaves; and smear of NAA—lanolin paste; and 50, and 100 p.p.m. pure NAA. Out of these 7 treatments, only NAA in lanolin increased the grain yield in wheat, N.P. 710, the increase being due to increase in ear number. There was no effect on Pb. C. 228.

In a field experiment, involving 3 varieties of wheat, N.P. 718, N.P. 770 and N.P. 799 and seed-soaking treatments prior to sowing, namely, soaking in 2, 4-D solution of 4 different concentrations, 0, 0.01, 0.05 and 0.1 p.p.m. for 24 hours and repeated soaking in water and drying, it was found that none of the treatments increased the yield over that of water-treated control.

Weed control.

Jungli ber (*Zizyphus rotundifolia*).—The effect, on mortality, of spraying with 2, 4, 5-T at the rate of 2½ gallons per acre, digging up to a depth of 2 feet and removal and cutting to ground level, varied as 84, 74 and 39% respectively. About 80% mortality occurred under CMU application at the rate of 40 lb. per acre to a piece of land infested with *ber*.

Kans (*Saccharum spontaneum*).—Among potassiuu chlorate at 500 lb. per acre, sodium salt of TCA at 80 lb. per acre, and CMU at 40 lb. per acre, the last one controlled *kans* most effectively, there being very little regrowth even after a year.

Dub (*Cynodon dactylon*) and *motha* (*Cyperus rotundus*).—TCA at 100 lb. per acre was more effective on *dub* than CMU at 20 lb. per acre; the CMU treated plot had no other vegetation except some *dub*, whereas the TCA-plot sustained a good growth of dicot weeds. Both compounds were equally effective on *motha*.

29. Plant nutrition

In a field experiment, involving 3 wheats, N.P. 710, N.P. 718 and N.P. 797, and application of manganese, zinc, boron, copper and molybdenum to soil and as spray, only boron, applied to soil at the rate of 2.3 lb. per acre, increased the yield over the NPK control (30 lb. N, 40 lb. O_3 , 30 lb. K_2O per acre) by 3.7 mds. per acre. In two separate field experiments, one with paddy and the other with wheat, the effect of "fritted trace elements" was compared with that of manganese, zinc, boron, copper and Molybdenum applied individually. None of the treatments increased the yield over the control.

30. Lodging in wheat

Breaking strength of the first above-ground internode, shoot weight and root/shoot ratios were determined in N.P. 710, N.P. 718, N.P. 770, N.P. 775, N.P. 781 and N.P. 797, after ear emergence, under two levels of nitrogen, 0 and 20 lb. N per acre, applied at sowing and 35, 70 and 105 days after sowing respectively. The treatments had little effect on the characters measured. The ratio, breaking strength/shoot weight diminished in the order: N.P. 770, N.P. 797, N.P. 781, N.P. 718, N.P. 710 and N.P. 775; the root/shoot ratio diminished in the order: N.P. 718, N.P. 770, N.P. 781, N.P. 775, N.P. 710 and N.P. 797. The varieties N.P. 770, N.P. 718 and N.P. 781 appear to be more resistant to lodging than the other three varieties according to these criteria.

31. Indian Central Oilseeds Committee Scheme for Physiological Investigations on Autotetraploids of some Oil-seed Crops.

In a comparative study of the growth of diploid, T22, and a tetraploid elite A of *toria*, (*Brassica campestris* var. *toria*), it was found that the tetraploid was superior to the diploid in respect of leaf number and size, percentage of fruit set and seed size. It did not, however out-yield the diploid because of its inferiority in number of secondary branches and seed number per silique. It appeared that further selection, also on the basis of secondary branches, might increase the yield potential of the tetraploid. The tetraploid did not appear to be more drought-resistant than the diploid.

32. The Indian Council of Agricultural Research Co-ordinated Scheme for Investigations on Micro-nutrients.

Observations on grape fruit, mandarin and malta trees in the Institute Orchard, suffering from chlorosis and "die-back", indicated that iron as well as zinc deficiency was involved.

PLANT INTRODUCTION AND SYSTEMATIC BOTANY

33. Plant Introduction

The work is being done since 1946 under a nucleus organisation financed by the Indian Council of Agricultural Research.

During the year, 1,457 samples of seeds of crop plants and other economic plants were imported from various foreign countries. Eight hundred and thirty-five samples of seeds were collected from within the country; this collection comprised a large number of varieties of tropical and subtropical vegetables. One hundred and four samples of miscellaneous wild growing species, mainly grasses and legumes, were also collected from within the country. The total collection, both indigenous and exotic, new totals 11,971.

Further progress was made in the evaluation and utilization of some of the new introductions. In tomato, two Dutch varieties, "Renova" and "Waltham Mold Proof Forcing" and the large fruited American variety, "Ace", gave a good performance. A closed anther mutant in the tomato variety, "Jhon Baer", was obtained from the United States and this is being used in investigations on hybrid seed production in tomato. The various lines of onion varieties constituting two sets for hybrid seed production formed bulbs satisfactorily. The American onion variety, "Red Creole", was observed to be a very good storage type; there was less rotting of bulbs (5.4%), loss in weight (17.4%) and the sprouting was also late. Since this variety is comparatively low yielding, it appears to be useful chiefly as a breeding material for improving the storage qualities of the good yielding local varieties.

Two Japanese onion varieties, T. 1 and T. 4, compared favourably with other promising white and yellow varieties.

Two early varieties of watermelon, "Asahi Yamato" from Japan and "New Hampshire Midget" from the United States, showed very good performance. An East African variety of soyabean, N. 49, was found to be almost completely non-shattering. An American cowpea variety, Cream No. 40, produced attractive looking, uniformly white, bold grains; it is a bush type and matures in about 70 days as a monsoon crop. Amongst the earlier introductions, a variety of sesame received from Cyprus stood very well against wilt caused by *Macrophomina phaseoli*. The vegetable cowpea, "Pusa Barsati" (Philippines Early), gave very encouraging results when grown at Delhi as a purely rainfed crop in rather poor brown light soil.

Selected varieties of peas were compared in yield trials for their suitability as vegetable and grain varieties. In the early fruiting group, "Asauji" gave a calculated yield of 104 mds. of green pods per acre. Amongst the mid-season varieties, "Bonneville", with a yield of 124 mds., topped the list. As a grain variety, the smooth, bold seeded variety, "Kali Nagni", gave best performance, yielding about 41 mds. per acre.

Maize varieties, Jellicose, Capiten, Cornelli II and F. F. (M.S.) 13 from Central and South America and Venezuela No. 1 significantly out-yielded K.T. 41, a promising north Indian maize variety.

34. Systematic Botany

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Herbarium.—About 100 specimens were collected and about 900 specimens were mounted, stitched and identified during the year. The items in the Herbarium now total 6,000. About 200 specimens were sent on exchange to the Dehra Dun and the Calcutta Herbariums.

Botanic Garden.—A small botanic garden has been established in the Division. A rock garden has been raised and a pond has been constructed for the purpose of growing aquatic plants.

Variability of Indian wheats.—Wheats of Bihar, West Bengal, Assam and Orissa comprising 144 types, were studied and classified according to their morphological and agronomic characters. Also, 113 types from Uttar Pradesh and Delhi State were studied. Type W.C. 759 from Bihar give the best performance and it belongs to the botanical variety, *Triticum aestivum* L. var. *aureum* (Link) Mansfield. Key to all the types has been prepared on the basis of their morphological and agronomic characters. Three wheat types have also been obtained from Nepal and preliminary observations regarding their growth and performance have been recorded.

Study of Weeds.—Six quadrats, of 10 meter square each, were located in different parts of the Indian Agricultural Research Institute Farm in connection with a quantitative study of weeds and their frequency of occurrence. Every month, the frequency of occurrence of weeds, their flowering and fruiting, and succession of new weeds were studied twice in each quadrat. The maximum quantity of weeds occurred in Todapur and the Central College of Agriculture Orchard area, among six places studied. At Todapur, *Sorghum halepense* (54.5%) and *Digitaria bifagiculata* (17.0%) were the predominant weeds during the kharif season: while *Cyperus rotundus* (70.0%) and *Euphorbia geniculata* (7.5%) were the predominant ones in the Central College of Agriculture's orchard area during the same season. During rabi, the most prevalent weeds were *Sorghum halepense* (90.0%) and *Cyperus rotundus* (7.%) at Todapur, and *Cyperus rotundus* (52.0%) and *Anagallis arvensis* (12.0%) at Central College of Agriculture orchard.

Trial of Kochia indica.—Studies on the growth and distribution of *Kochia indica* were continued. Seeds were distributed to several institutions in India and abroad.

35. Horticulture

The unplanted area in the Experimental Orchard was planted with various fruit trees, including collections of orange and lime varieties, custard apple and guava. Plantings were done according to the square system.

In the area taken over from the Central College of Agriculture, seventeen varieties of grapes had been planted in 1952. Among these, two varieties, Bokri and Black Muscat, came into bearing in June, 1955. Bokhri, which had yellowish green berries, was the sweeter of the two but had smaller bunches. Several pomegranate trees of the variety, "White Muscat", planted in 1952, also came into bearing this year.

The orchard was inter-cropped with vegetable crops like bhindi, brinjal, tomato, gourds, cowpeas, peas, potato, chillies, spinach and garlic and other crops like linseed and watermelon. By this means, seeds of several improved New Pusa varieties of these crops were multiplied and also about four hundred rupees worth of vegetables were sold. Legumes were grown in some areas both for purposes of fodder and green-manuring.

In order to evolve good varieties of muskmelon, 179 samples of different varieties were obtained and tested for thinness of skin, colour, thickness and taste of flesh and fragrance and sweetness of juice.

The nursery area of the orchard was extended from 0.3 acres to 1.2 acres during the year. About 14,500 plants were raised in the nursery, out of which 2,060 plants were sold to the public. About 2,500 seedlings of vegetable plants like cauliflower, cabbage, brinjals, tomatoes, etc., were also sold.

36. Botanical Sub-station, Pusa

As in previous years, the main work at the Sub-station included (i) maintenance of crop collections, both indigenous and exotic, and testing their performance under north Bihar conditions, (ii) breeding and selection work in crops like wheat linseed, pigeon pea, maize, etc., to evolve varieties suitable for the north-eastern tract of the country, and (iii) multiplication of foundation seed stocks of N.P. varieties of crop plants for distribution to growers in that

region. The Sub-station forms an important centre for breeding rust resistant wheats under the Co-ordinated Wheat Rust Control Scheme. The other Divisions of the Institute also carry out certain of their experiments at this Sub-station.

The crop season during the year under report was favourable to the wheat crop and seeds of several improved varieties were multiplied on a large scale and distributed. Seeds of promising N.P. strains of oats, barely, maize, pigeon pea, lentil, gram, linseed, sesamum and safflower were also multiplied and distributed. In a yield trial of autotetraploid *toria* the tetraploid yielded 365 lbs. per acre as against 313 lbs. given by the diploid.

An exotic variety of jute, E.C. 4142, grew much taller than the local varieties and gave 40% more fibre yield than the control. In tobacco, N.P. 219 and N.P. 222 showed good growth and leaf development and in potato, H. 45 gave the highest yield. About 800 F¹ plants were raised from the 40 plants selected last year in the cross between the tomato varieties, "Sioux" and "Improved Meeruti". About 40 plants from 12 progenies were selected for further study on the basis of earliness, uniform maturity, number of fruits per bunch, fruit size and absence of cracking of skin and green-stem end.

The Permanent Manurial and Rotational Experiments and the New Manurial Experiments were carried out in conjunction with the Divisions of Agronomy and Chemistry. A total sum of Rs. 11,791-8-6 was realised during the financial year ending 31st March, 1955, from the sale of improved seeds and other farm products.

PROGRAMME OF WORK FOR THE YEAR 1955-56

1. Improvement of Indian wheat with special reference to evolving varieties resistant to rusts, smuts, bunt, drought and lodging.
2. Study of the suitability of N.P. wheats and other breeding material to irrigated and *barani* conditions and to special conditions like rich soils, late sowing, etc.
3. Study of milling and baking quality in wheat varieties.
4. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon-pea.
5. Genetics of rust resistance and other characters in wheat and of rust and wilt resistance in linseed.
6. Breeding extra-long staple *hirsutum* cottons.
7. Trials of recently-evolved N.P. strains of crop plants like wheat, linseed, pigeon pea, tomato, etc., in the different States of India.
8. Investigations on the utilisation of hybrid vigour in maize, tomato, onion, *bhindi*, and radish. Trials of Indian and foreign hybrid maize in different States.
9. Breeding of early-ripening and high yielding varieties of bajra and fodder and grain varieties of *jowar*.
10. Breeding of some pasture grasses and legumes for Northern India.
11. Study of wild relatives of crop plants and their utilisation in plant breeding, e.g., in wheat, *bhindi*, *sesamum*, etc.

12. Improvement of chilli through breeding varieties resistant to diseases.
13. Improvement, by breeding better varieties, of essential oil-bearing plants like coriander, *somf*, *ajwain*, etc.
14. Induction and study of polyploidy in oilseed crops like *Brassica* and linseed and fodder crops like berseem, *senji* and *Cenchrus ciliaris*, as a method of crop improvement. Yield trials of some promising lines of tetraploid *toria*.
15. Cytogenetical studies in *Triticum* species and of interspecific and intergeneric hybrids involving *Triticum*-Monosomic analysis for location of genes for rust resistance and other characters on different chromosomes.
16. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.
17. Studies on the nature of differentiation of tuber-bearing and non-tuber-bearing species in the genera *Solanum* and *Ipomoea*.
18. Induction of mutations in crop plants through the use of chemical agents and radioactive isotopes.
19. Studies on the incidence and induction of pollen sterility in crop plants.
20. Application of embryo culture technique to overcome embryo lethality in distant crosses.
21. Improvement of cytological technique.
22. Physiological studies on drought and lodging resistance in wheat.
23. Physiological analysis of factors concerned with yield in wheat.
24. Influence of light and temperature on growth and development in wheat.
25. Physiological aspects of plant nutrition in wheat : studies on the relation between varietal differences in the uptake of nutrients.
26. Plant hormones—investigations on the role of different hormones on growth and development in wheat and on the usefulness of hormones as weedicides.
27. Plant physiological studies in relation to the die-back disease of citrus.
28. Plant introduction and collection of indigenous plants of economic value; their maintenance, evaluation and trials in Delhi and other States.
29. Horticulture—extension of the garden area for purposes of research work on fruits and vegetable plants and supply of nursery plants.
30. Intensification of multiplication and distribution of seeds of improved N.P. varieties of field end vegetable crops.
31. Testing and certification of seeds of vegetable crops.

3. REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

(Dr. S. P. Raychaudhuri)

The research activities of the Division of Soil Science and Agricultural Chemistry were reorganised at the close of 1954 under five sections namely, Agricultural Chemistry (including Soil Fertility and Soil Microbiology), Soil Survey and Soil Physics, Physical Chemistry, Plant Chemistry (including Organic Chemistry and Biochemistry) and Physics. The problems under investigation include studies on manures and fertilizers, soil survey and land utilization, soil colloids and clay minerals, preparation of pesticides, quality of crops and micro-elements. Besides, investigations have been carried out under Indo-U.S. Agreement on Soil Fertility and Fertilizer Use, on the applicability of new fertilizers under different soil and climatic conditions and formulations of manurial schedules, keeping quality of new fertilizers while stored under different climatic conditions and use of radio tracer technique to study the phosphorus deficiencies of Indian Soils.

I. AGRICULTURAL CHEMISTRY

(a) Soil Fertility

1. *Fertilizer value of dicalcium phosphate on paddy, berseem and wheat.*

In the third year of the experiment, the fertility of the soil, improved by paddy-berseem rotation, was reflected in the yield of control increasing from 800 lb. to 2,000 lb. of paddy grain. Application of dicalcium phosphate or superphosphate in combination with nitrogen gave respectively 12 and 10% increased yields which were not significant. Bone meal was ineffective.

The residual berseem grown in *rabi* showed significantly better response under superphosphate than dicalcium phosphate alone. With nitrogen in combination, this difference between the two was not significant. Bone meal in combination with F.Y.M. also gave significant response.

On calcareous soil at Pusa, wheat gave equally significant response to dicalcium phosphate and superphosphate in combination with 40 lb. N per acre. Bone meal became effective and gave response only in combination with F.Y.M.

2. *Fertilizer value of ammonium chloride and ammonium sulphate-nitrate*

Trials on paddy (NP 130) were continued for the second year at Karnal. Both ammonium chloride and ammonium sulphate-nitrate gave significant increase in the yield of paddy similar to that obtained with ammonium sulphate. The differences in yields with different forms of nitrogen were not significant. Increase of nitrogen dose from 20 lb. to 40 lb. per acre did not show further response.

3. *Effect of dipping roots of paddy seedlings in fertilizer solution before transplanting, on growth and yield of paddy.*

During the 2nd year of this experiment, increased yields of paddy of the order of 13% over control were obtained in field trials at Karnal by treatment of roots with emulsion of nitrogenous fertilizers in soil. In small scale field experiments at Delhi on nitrogen and

phosphorus deficient soil, maximum increased yield of 37% over control was obtained by treatment of roots with a combination of ammonium sulphate and superphosphate. The results are, however, not statistically significant due to a large variation.

Seeds candied with a paste of soil containing 10% of the weight of seeds of ammonium phosphate gave a significant increase in the yield of wheat grains.

4. *Amelioration of saline and alkaline soils*

Laboratory experiments on germination of maize showed that application of 1% charcoal to soil reduced the toxicity of NaCl and Na_2CO_3 from 0.3 to 0.6%. Beneficial effect on germination was also observed when seeds were coated with a paste of dung containing gypsum before sowing.

Physical properties of alkali soils containing 0.3–0.8% Na_2CO_3 were considerably improved by ignition of soils at 300°C . The treatment improved germination percentage from 10% in untreated soil to 70% in ignited soil containing toxic amount of 0.8% Na_2CO_3 .

5. *Effect of organic manure (F.Y.M.) and inorganic fertilizers and their combination on the yield and quality of crops using seeds from the same plot for sowing in the following year.*

Experiments were started with wheat variety NP 761 in small raised plots (1/100 acre during last *rabi* with (i) F.Y.M. at 80 lb. N per acre (ii) Ammonium Sulphate at 40 lb. N plus superphosphate at 80 lb. O per acre and (iii) F.Y.M. at 40 lb. N plus ammonium sulphate at 20 lb. N plus super at 80 lb P_2O_5 per acre. For the first two years, yields of wheat have been about the same for all the treatments. In the case of maize crop, one season's data showed that the mixture of organics and artificials gave somewhat lower yields than the other two.

6. *Increasing the availability of phosphate by composting*

Pot experiment with *marua* and berseem showed that a preliminary fermentation of cattle shed refuse plus superphosphate before addition to the soil gave a higher crop yield than the application of superphosphate to soil along with separately fermented refuse material. This confirmed the work reported last year.

7. *Development of an economic plant and process for production of fuel gas and manure by anaerobic fermentation of cow-dung and organic waste suitable for adoption in the villages.*

A small size model of village gas plant costing about Rs. 200/ was set up at this Institute in February, 1955. During the summer months, it yielded about 50 cu. ft. of gas per day, sufficient to meet the fuel needs of an average village family. A second slightly improved model also suitable for village homes is being set up.

8. *Chemical composition of the wheat plant as a guide for assessing the manurial requirements of the wheat crop in Delhi soil.*

Pot culture experiments with wheat at different levels of N, K and P showed that the chemical composition of the above ground plant, sampled at the tillering (2 months) stage, had a direct relationship to the quantity of fertilizer applied and the final yield obtained.

9. *Comparative study of the methods for finding out the major nutrient element deficiencies in the different types of soils.*

Studies using lettuce as an indicator plant showed certain deficiency of N and K and a probable deficiency for P_2O in the Delhi soil used for growing tomato crop in pot culture experiments. Results with the SIOUX and **recruit** variety of tomato showed that maximum yield was obtained with $N_{175}P_{120}K_{30}$ and $N_{175}P_{120}K$ treatment.

10. *Effect of continuous application of fertilizer and manures on the carbon and nitrogen status of the soil and its microbiological properties.*

Soils from the Permanent Manurial Experiments at Pusa (Bihar), Coimbatore and the Experimental plots at New Delhi (Main Block 13B and 7C) were tested. The data are being examined.

11. *Physical properties of certain chemical fertilizers under storage conditions*

Certain new types of fertilizers were examined for their behaviour during storage at 20 selected centres under varying conditions of climate, types of packing materials and varying condition of godown arrangements (*Pucca & Kutcha*). The storage quality of nitro-phosphate was found to be extremely unsatisfactory and that of ammonium nitrate was quite satisfactory when packed dry in 5 ply paper bags with 2 moisture proof plies and jute over bags. Urea and ammonium sulphate showed a tendency to hard caking which could be prevented by packing them dry in alkathene liners with jute over bags. Triple superphosphate damaged bags and could be stored in thick walled alkathene liners with jute over bags. Ammonium phosphate, granulated, kept well under all types of packing.

12. *Available phosphorus in soils and phosphorus fertilizer utilization by wheat/oats and rice*

The method for estimation of radio-phosphorus in soil and plant materials was standardised. Two replicated pot-culture experiments using radioactive phosphorus were completed. The first was with oats on six different soils and the second with rice (P.T.B. 10) on 19 different soils. The treatments were control (no phosphate), 40 lb., 80 lb. and 160 lb. P_2O_5 per acre as radioactive superphosphate. A basal doze of $N_{100}K_{20}$ and all trace element was given. Data on yield, uptake of total phosphorus, radio-phosphorus, % phosphorus in plant material derived from the fertilizer were recorded. It was found that many of our soils were deficient in phosphorus and showed good phosphate response.

13. *Measurement of surface phosphorus of soils*

Surface phosphorus of soils is considered to have definite relationship with phosphorus available to plants. The technique for measurement of surface phosphorus by isotope exchange with P^{32} was, therefore, set up. 32 soils from pot culture studies have been analysed for the surface phosphorus. The data are being examined.

14. *Development of a soil phosphorus test.*

In an attempt to develop a soil test for phosphorus, several methods for extraction of available phosphorus were tried in soils collected from (a) pot culture experiments in which 48 different soils were used and (b) T.C.M. Agronomic Trials. The soil test values

for phosphorus by different methods were correlated with the percentage yield response due to phosphorus. The Olsen method gave consistently highly significant correlations. In the Olsen method if the value of a soil test for phosphorus is less than 20 lb. P_2O_5 the soil is deficient and phosphorus fertilization will increase the yield.

15. *Rapid soil tests*

A soil testing laboratory has been set up under the Indo-U.S. T.C.M. Agreement with the object of developing a rapid soil testing service for providing advisory services to the cultivators, extension worker and village level workers on the fertility status of the soil and their manurial requirement.

The alkaline permanganate method along with the standard incubation method was adopted for the estimation of available nitrogen in about 83 soils from T.C.M. Dumka cultivators' field experiments. The values of nitrogen extracted by the alkaline permanganate method varied from 6.9 to 17.9 mg./100g. The co-efficient of correlation between nitrogen extracted by this method and fertilizer response to nitrogen was significant at 1% level. Preliminary results indicate that available nitrogen less than 175 lb./acre is likely to respond to nitrogen fertilisation.

Available potassium has been estimated with normal ammonium acetate in 83 soils from Dumka and 32 soils from Bihar. The correlation of available potassium with its response to paddy crop is being worked out.

16. *Potassium status of soils*

Forty-four soil profiles from different parts of the country were analysed for HCl soluble, exchangeable and water soluble potassium. The data are being examined.

(b) *Microbiology*

17. *Inoculation of soil, seed and crop with symbiotic and asymbiotic nitrogen fixing organisms.*

Attempts are being made to induce growth of symbiotic and asymbiotic nitrogen fixing organisms on cultivated crops by inoculation of soil, seed and the crop with a view to obtain nitrogen fixation and greater crop yields. Before inoculation, the organisms are acclimatised to the host plant by repeated culture in media containing the powdered crop plants.

18. *Studies on the Rhizobia of wild leguminous plants*

Pure cultures of rhizobia have been isolated from wild leguminous plants and classified into well-known cross inoculation groups. It is proposed to inoculate common cultivated legumes with the rhizobia and study the yields.

The cause of absence of nodules in some non-nodulating species of leguminous plants is also being studied along with the question if these plants are able to fix atmospheric nitrogen by themselves.

19. *Studies on Azotobacter.*

Ways to improve nitrogen by *Azotobacter* by use of minerals, trace elements, different energy sources and humus from different forms of organic matter are being studied.

20 *Microbiological decomposition of herbicides*

A sample of Delhi soil was enriched with respect to the organisms decomposing methyl-chloro-phenoxy acetic acid by successive additions of this herbicide. Attempts are in progress to obtain a pure culture of the causative organism from this source.

21. *Effect of cations and anions on the rate of nitrogen fixation by Azotobacter*

Cobalt at a concentration of 0.02 p.p.m. was found to accelerate the rate of nitrogen fixed by *Azotobacter*, while this element was toxic at a conc. of 10 p.p.m. Nickel at a conc. of 1 p.p.m. accelerated nitrogen fixation, but completely inhibited it at a conc. of 4 p.p.m. Ferric ion accelerated nitrogen fixation at a concentration of 1 p.p.m., but inhibited at a conc. of 10 p.p.m.

22. *Studies on the relative efficiency of ammonium phosphate and some phosphatic fertilizers and methods of increasing their availabilities.*

Soil samples, from pots in which wheat crop was grown last year with 60 and 120 lb. P_2O_5 per acre in the forms of different phosphatic fertilizers, over a basal dressing of 40 lb. N were analysed for their available P_2O_5 contents by Dyer's 1% citric acid extraction. The average figure of five replications under each treatment showed that the application of 120 lb P_2O_5 per acre in the form of nitrophosphate, bonemeal, ammonium phosphate and triple super increased the average P_2O_5 values from 0.0093 to 0.0140, 0.0114, 0.0106 per cent respectively. At 60 lb. P_2O_5 level of application, there was hardly any improvement in the average P_2O_5 contents. Dicalcium phosphate, even at 120 lb. P_2O_5 level, did not show any increase in the average P_2O_5 value. Further work is in progress.

23. *Iron and manganese relationship in some typical paddy and other soil profiles*

Eleven soil profiles, three from Bihar, two from U.P., one from Karnal and five acid soil profiles from Darjeeling District (West Bengal) have been examined and the soil samples from them have been analysed for the various chemical and mechanical constituents. The ferrous iron has been estimated colorimetrically by the dipyriddy method and the total manganese spectrographically. The results are being examined.

24. *Nature of typical saline and alkaline soil profiles in Northern India*

Six soil profiles, two from Bihar (Pusa), two from Delhi State, one from U.P. and one from Karnal, have been examined and, in all, 30 soil samples have been collected for these investigations. The soil samples have been analysed for their chemical and mechanical constituents. The results are being examined.

II. SOIL SURVEY AND SOIL PHYSICS

25. *Standardisation of nomenclature, morphology and taxonomic units of soils to arrive at a normal profile with its morphological features.*

(a) *Black soils of Madhya Pradesh.*—Black Soil occurring on basalt, granite and gneisses have been studied. To compare our black soils with those of the U. S. A., two black soil profiles of Houston clay and Taintor silty clay loam which are said to be akin to our regur soils were obtained from the U.S.A.

The chemical composition of the parent materials differ in their silica, alumina and Fe_2O_3 content. The content of alumina and iron in Indian Black soils is higher than that of U.S.A. In our soils the R_2O_3 varies from 25 to 35 per cent while those of U.S.A., it is between 15 and 22 per cent. The cation exchange capacity of clay fraction from soils occurring on basalt is between 49.0 and 69.0 m.e./100 gm. while that of granitic origin is between 45 and 46 m.e. In U.S.A. soil, the Houston clay has b.e.c. of the order of 75 to 90 m.e./100 gm. and in Taintor silt clay it is between 66 and 70 m.e.

(b) *Laterites and lateritic soils of Travancore-Cochin and Kutch.*—Examination of several profiles of Malabar and Kanara Districts of Madras has revealed the existence of basic rocks like dolerites, basalts and also gneisses of intermediate acidity and laterites have developed in all these formations. The individual horizons in order of occurrence are (i) red soil, loam to gravely loam, (ii) crumbly laterite, (iii) true laterite, (iv) immature laterite, (v) kaolinitic layer, (vi) decomposed rock and (vii) unweathered rock. Silica is frequently found as secondly quartz within the laterite horizons and sometimes the secondary quartz layer (sand) is found intervening the kaolinitic layer and rock. Not all horizons exist in every place. The available data indicate that the parent materials influence the development and composition of laterites. Thus the laterites on basalts and dolerites contain less silica and more iron oxides than those developed on acidic rocks.

(c) *Alluvial soils of Rajasthan.*—In connection with the Desert Afforestation Research Project, soils from various places were examined. Over a major part of the tract, the soils are sand to sandy loam and rarely loam. Lime concretions were met with sometimes at all depths of the profile. Two soil profiles of Karnal were examined. Soil types were loam and silt loam. Ferruginous concretions were present in a distinct layer in the first profile below 30 inches.

(d) *Soils of Simla.*—Two soil profiles were collected at 7,000 and 8,000 ft. elevations and were analysed for their physical, chemical and mineralogical properties.

26. Survey and mapping of Delhi soil

Under the Intensive Cultivation Scheme, soil survey and mapping of nine villages was completed. The main soil types are sandy loam, loamy sand and sand. A consolidated soil map of the 19 villages is being prepared.

27. Studies on saline and alkaline soils and their reclamation

Reclamation work in the Botany Division farm area was extended to other three plots. At Nilothi, an experiment with gypsum alone and gypsum plus organic matter on an alkali soil has been started. Gypsum seems to have improved the soils both at I.A.R.I. and Nilothi.

28. Studies on soil structure

Effect of manures and fertilizers on aggregation of Indian Agricultural Research Institute soil.—Incorporation of superphosphate, ammonium sulphate and F. Y. M. in varying doses in soil has shown that there is a possibility of getting higher percentage of water-stable aggregates.

29. *Influence of soil conditioners on soil structure*

Experiments conducted with Krilium, Acrotil and Poly-ack have shown that these soil conditioners improve the soil structure considerably by bringing about increased aggregation. In pot culture experiments, crops *Setaria italica* (Kangric) and wheat gave higher yield with Krilium treatment. It is also seen that the application of Krilium with gypsum improves the structure of alkali soils better than gypsum alone.

30. *Soil and water conservation (Qumaruddin Nagar).*

Bunding programme was completed. An improvement was noticed in the quality of the well water.

31. *Soil and land utilization survey of Little Rann of Kutch*

Over 100 soil samples were analysed. The distribution of soluble salts in the profiles, potassium and magnesium content in particular, gave clear indications of areas being approached by sea water. The soils on the basis of field and laboratory examination have been classified and their behaviour under reclamation and probable time for reclamation have also been assessed. The soils after desalinization did not show any bad physical condition. The entry of sodium into exchange complex was prevented by the gypsum present in the soils. In the light of the available information, it was concluded that nearly 3,00,000 acres of land could be reclaimed in the first instance and the rest of the area requires costly measures.

III. PHYSICAL CHEMISTRY

32. *Physico-chemical studies on the formation of saline and alkaline soils at Pusa and their reclamation.*

Studies conducted this year have confirmed the earlier finding regarding the formation of the alkaline patches at Pusa as due to the lateral movement of underground water from certain underground water mounds in those fields, sweeping and collecting salts in this process and to an ascent of the salt water so formed at patches of greater initial permeability resulting in the formation of alkaline patches and a deterioration of the soil permeability. It was found that a calcium concentration of the order of 0.002 Molar or more is required to depress the pH of these patches to 8.5 in the Gouri and Mushar fields and is beyond what can be dissolved by the CO₂ pressure of the roots under any crop cover. The gypsum requirement of these patches increased with the advance of the summer, being in April 2½ times the value in January but decreased if applied in instalments between flooding over that required for a single lot application. These patches can, therefore, be reclaimed by (i) undoing the adverse underground water movements by pumping from the mounds for purposes of irrigation after mixing wherever necessary with the requisite quantity of river water, (ii) the application of gypsum between floodings during the optimum season after installing drainage, and (iii) the early establishment of the suitable crop cover on those patches.

33. (a) *Studies on the formation and characterisation of clays and clay-minerals in soils*

The curves connecting cation exchange capacity with pH as well as electro-osmotic velocity with pH for montmorillonite, illite and kaolinite were found to be distinct and characteristic of these clay mineral types being also different from those of the free oxides of silicon, iron and aluminium. X-ray and D.T.A. analysis of synthetic precipitates confirmed last year's finding that there was a structural change in the aluminosilicate precipitates when the SiO₂/R₂O₃ ratio was about 10.0.

(b) Studies on the formation and characterisation of clay-humus complexes

The nature of the fertile and infertile groups of clay-humus complexes of Tyulin were investigated by analysing these fractions in compost prepared of F.Y.M. with the different clay-minerals. The fertile group was found to be more in the compost with montmorillonite while the infertile group dominated the compost with kaolinite. It was also found by mixing the isolated group I fertile colloid with montmorillonite, that there was an increase in the cation exchange capacity of the mixture, while there was a decrease in this capacity when the infertile fraction was mixed with kaolinite.

IV. PLANT CHEMISTRY

(a) Organic Chemistry

34. Synthesis of organic thiocyanates and phosphate based on oils and fats

Methyl ricinoleate as well as castor oil were converted to the monochloracetate by treatment with chloracetic acid. The chloracetates were converted to thiocyanates by treatment with ammonium thiocyanate. The resulting thiocyanates showed no insecticidal activity.

35. Chlorinated carenes as insecticides.

Previous work in this laboratory had shown that carene chlorinated to 45 to 50 per cent chloride content is a good insecticide but this chlorination took up to 140 to 160 hours. Attempts were, therefore, made to shorten this period by using catalysts. The presence of about 5 per cent HCl was found to catalyse the reaction in the earlier stages upto about 45 per cent chlorine content in 30 to 35 hours. Chlorination up to 53 per cent chlorine content can be done in 10 to 12 hours in the presence of 0.5 per cent iodine.

36. Synergists and formulations for insecticides

The total benzene extract of *Myristica attenuata* which showed good anti-oxidant activity was tested against pyrethrins and preliminary observations showed good promise as a synergist.

37. Biogenesis of fats in ripening seeds

A modified method for the estimation of iso-oleic acid has been developed and 25 natural fats were analysed. Animal oils and fats show up to 7 per cent iso-oleic acid while vegetable oils show upto 0.5 to 1.0 per cent only.

38. Estimation of tocopherols in small quantity of oilseeds

It was found that free acids and salts of some organic acids interfere with the direct determination of tocopherol in oils and fats. Evidence was obtained to show that this inhibition was due to peroxides. It was found that oils freshly extracted with purified sulphuric ether did not contain the inhibitor. A method was developed whereby free tocopherol content of oil could be estimated using 0.10 to 0.15 gm. of seed.

39. Estimation of oil in small quantity of seeds by cold percolation method

It has been found that if a seed is ground with glass powder and anhydrous sodium sulphate and packed in a percolator over a bed of anhydrous sodium sulphate, the oil can be extracted quantitatively in the cold by percolation with a small amount of solvent. The method is rapid and inexpensive.

40. Development of antioxidants for fats and oils

A crystalline phenol m.p. 97-98° C. from *Myristica attenuata*, a crystalline neutral substance of m.p. 123° C. from the same and a crystalline phenol m.p. 280-210° C. from *Myristica canaris* were found to have some antioxidant activity against vanaspati. Extracts of seeds as well as of mace of *Myristica malabarica* showed good antioxidant activity for various oils and fats at 60 and 98° C. The extract compares favourably with butylated-hydroxy-toluene a commercial product in its activity.

40. Development of antioxidants for fats and oils.

Mercuric acetate addition products of fatty acid esters and glycerides have been found to show good fungicidal properties (tested by the Mycology Division), so also mercuric acetate addition products of longifolene. Methods have been worked out to prepare these in maximum yields and with minimum decomposition.

Reaction products of the above addition compounds with sodium halides have been prepared and are being tested for fungicidal activity. These halogenated products are much more stable than the original mercury acetate adducts. The reactions involving the formation of these products are being studied further.

(b) Biochemistry

42. Nutritive value of crops as affected by manurial, cultural and storage factors

(a) *Vitamin content of wheat as affected by manures and fertilizers.*—The composite samples of wheat grains raised in the 18 experimental plots in the Permanent Manurial and Rotational experiments at Pusa (Bihar) were analysed for their thiamine, riboflavin and niacin content. Riboflavin content was not much affected by the treatments while thiamine content increased in the plots receiving P-treatment. Niacin was also not affected by any treatment other than green manure and PK which showed slight increase.

(b) *The quality of wheat as affected by the spraying of urea solution.*—A replicated trial with wheat (NP 710) showed that spraying of wheat plants at flowering stage with dilute solutions of urea resulted in highly significant increase in the yield of grain protein per acre, the percentage of protein in grains and the weight of 1,000 grains, but did not show any significant increase in the yield of grains. It was also noticed that while grains from the no-spray treatment were mottled, spraying made the grains translucent.

(c) *Nutritive value of pure strains of Indian pulses.*—Estimation of Biological Value of pulses by the growth and the balance experiment revealed that their values were low. Studies were, therefore, done to examine if the Biological value of the pulse protein and their digestibility could be improved by supplementation with vitamin B₁₂ and methionine either singly or in combination. Vitamin B₁₂ alone did not affect their B.V. or digestibility while methionine alone considerably increased the B.V. when fed at 6 p.c. protein level. Methionine plus vitamin B₁₂ increased the B.V. still more.

(d) *Thiamine content of Indian pulses.*—A few samples of pulses grown in 1953 and in 1954 at Pusa (Bihar) were analysed for their content of thiamine. In certain cases, thiamine content of the same pulses differed in crops of two successive years. The content of thiamine in different pulses varied from 3.07 to 8.62 micrograms per gram.

(c) *Amino-acid content of grasses and legumes.*—A number of grasses and legumes were analysed for their content of methionine, cystine and tryptophane. The content of methionine ranged from 0.18 to 0.44% in the legumes and from 0.19 to 0.29% in the grasses. Cystine from 0.022% to 0.142 in the legumes and from 0.0087 to 0.044% in the grasses while tryptophane varied from 0.046 to 0.158% in the legumes and 0.02 to 0.099% in the grasses.

A few samples of *Vicia hirsuta*, *Lathyrus sativus* and *Vicia sativa* were also analysed for these amino-acids. Their content of methionine, cystine and tryptophane ranged from 0.184 to 0.315%, 0.123 to 0.163%, 0.08 to 0.125% respectively.

(f) *Quality of wheat as affected by micro-element fertilizers.*—In continuation of the work reported last year, a replicated trial was conducted to study the effect of copper, manganese, zinc and magnesium on the yield and the quality of wheat grains. The grain yield increased by the application of manganese, magnesium and a mixture of manganese, magnesium, copper and zinc in the soil as well as by spraying manganese and copper on the leaves. Foliar application of zinc and soil application of manganese and copper increased the protein content of grains.

(g) *Nicotinic acid content of wheat at different stages of grain formation.*—Nicotinic acid, both free and combined form, was estimated at different stages of grain formation, such as, at the milky, post milky and mature stages. The effect of foliar application of nitrogenous fertilizer like urea on the synthesis of this vitamin was also studied. The quantity of nicotinic acid in the grains increased with age and foliar application of urea did not affect the synthesis. Higher concentration of urea, on the other hand, inhibited the synthesis.

43. Studies on soil metabolism

Amino-acids excreted by legumes in the soil.—In continuation of the work reported last year, soil from plots growing berseem with 120 lb. P_2O_5 and no manure were analysed for amino-acids by paper chromatography along with the soil from a fallow plot. The quantity of amino-acid was largest in the plot treated with P_2O_5 and very faint in the fallow. The soil from the berseem plot receiving P_2O_5 contained free arginine and threonine which were absent in the other plots. This confirmed last year's observation.

44. Studies on plant enzymes

A new line of research on plant enzymes was initiated recently. Warburg apparatus recently received for this purpose is being standardised. It is proposed to undertake work on the oxidation-reduction system in the plant.

45. Nitrogen metabolism in berseem as affected by phosphatic fertilizers

Berseem was grown with no manure, 60 lb. P_2O_5 and 120 lb. P_2O_5 and various nitrogenous compounds including amino acids, amides, ammonia, nitrate, soluble nitrogen, insoluble nitrogen etc. were estimated in the leaves and stem tissues at different stages of growth as well as during germination with the object of studying the mechanism of synthesis of amino-acid in the plant. The soluble nitrogen fraction was also examined to assess its nutritional value. In the green leaves free aspartic and glutamic acid, asparagine, glutamine and serine alone could be detected and estimated. As the plant grew older some of the other amino-acids also appeared in the free state. The data are being analysed.

46. *Amino acid make up of the proteins.*

Several plant proteins were analysed by the microbiological and paper chromatographic techniques. Certain difficulties were experienced in the separation of certain amino-acids by paper chromatography. Methods for the separation for some of the amino-acids by buffered paper chromatography have been developed.

47. *Chemical composition and nutritive value of wheat (I.C.A.R. Scheme)*

Fourteen important varieties of NP wheat grown in three replicates at New Delhi and at Pusa (Bihar) were analysed for their chemical composition as well as for their content of B-vitamins. Their protein content varied from 8.7% to 11.4% in New Delhi samples and from 9.7 to 12.4% in Pusa (Bihar) samples. The variation in the content of phytin was from 247 mg. 100g to 377 mg. 100g in those of New Delhi and from 139 mg. 100 g. to 296 mg. 100 g in those of Pusa. Their diastatic activity expressed as maltose value also varies from 163 mg. to 264 mg. per 10 gm. in New Delhi samples and from 174 mg. to 299 mg. per 10 gm. in Pusa samples.

V. PHYSICS

48. *Spectrographic method of analysis*

(a) *Lundegardh technique.*—The optimum conditions of air and acetylene pressure were determined and found to be 24 lb./sq. in and 44 cm. of water respectively. This technique is being used for routine analysis of soils and plant materials for strontium, calcium, potassium, manganese, iron, sodium and magnesium.

(b) *Direct current arc technique.*—Boron is generally estimated by Direct Current arc technique using copper electrodes. Synthetic soil base was prepared from spec-pure chemical by sintering at 1,000 °C. and suitable standard mixtures of micro-elements were prepared. They were then arced at 5 amperes using copper electrodes and spectra were recorded on 'Ilford' chromatic plates. The intensities were measured on the non-recording microphotometer and working curves for boron, manganese, molybdenum and zinc were drawn. The method is being used for routine analysis.

49. *Micro-element status of Indian soils*

Micro-element status and complete physical and chemical composition of two profiles of Kashmir soils were determined. Saffron grew well in one soil (Profile I) but not in the other (Profile II). It was found that there was leaching down of CaCO₃ in profile I while in profile II there was no appreciable leaching. Texturally the soils were not much different. Difference was observed in the content of available phosphate. Profile I contained 0.069% while profile II contained 0.033 to 0.004%. Manganese, cobalt, copper and zinc did not appreciably vary in the two profiles.

50. *Micro-element status of some Indian grasses and forage crops*

It was reported last year that the yield of berseem was significantly influenced by the addition of molybdenum in black cotton soils. In order to study the residual effect of the previous treatment, 'Marua' was grown with 80 lb. P₂O₅ and 2 lb. MoO₃ per acre.

After the 'Maura' was harvested, experiments with berseem using tar black cotton soils, one from Hyderabad and the other from Nagpur were conducted. Along with these soils two Delhi soils (Top Block I and Middle Block C-4) were also used. The results are being statistically examined.

51. *Growth of wheat as influenced by the date of sowing (Micro and macro-climate)*

Wheat was sown on ten different dates starting from 1st October to 30th December, 1954. The growth characteristics and micro-climate observations were taken at regular intervals. The data are being analysed.

52. *Co-ordinated scheme for investigations on micro-nutrients (I.C.A.R. scheme)*

Analysis of a number of samples of healthy and unhealthy leaves of citrus was carried out to estimate both major and micro-elements. Several soil and sand samples were also examined.

PROGRAMME OF WORK FOR THE YEAR 1955-56

1. *Agricultural Chemistry*

(a) *Soil Fertility*

1. Fertilizer value of ammonium chloride, ammonium sulphate, dicalcium phosphate, ammonium phosphate, rock phosphate, liquid ammonia.
2. Effect of soaking seeds of wheat, maize and of dipping roots of paddy seedlings on growth and yield of the grains.
3. Determination of the manurial requirements of crops by different methods.
4. Experiments in composting.
5. Development of rapid methods for soil tests.
6. Phosphorus fertility status of soils by Radio Tracer investigations.
7. Development of an economic plant and process for production of fuel gas and manure from cowdung and organic waste.
8. Effect of heat treatment on the physical properties of alkali soils and suitability for crop growth.
9. Fixation, exchange and movement of phosphorus in soils.
10. Nature of typical saline and alkaline soil profiles in Northern India.
11. Studies on the potassium status of Indian soils.
12. Effect of continuous application of fertilizers and manures on the carbon and nitrogen status of plants and soils and their microbiological activities.

(b) *Microbiology*

13. Studies on soil, seed and crop inoculation with bacterial cultures
14. Activation of *Azotobacter* with and without presence of cellulose decomposing organisms.
15. Studies on the symbiotic fixation of nitrogen.
16. Microbiological decomposition of herbicides.

2. Soil Survey and Soil Physics

(1) Studies on the genesis and nomenclature of the Black Soils of Rajasthan, Madhya Pradesh and Madhya Bharat; Laterite and Lateritic soils of Travancore-Cochin and Kutch; and Alluvial soils of Rajasthan and Pusa.

(2) Studies on saline and alkaline soils and their reclamation.

(3) Studies on soil conditions, soil structure and soil moisture.

(4) Soil fertility and fertilizer status of Indian soils. (All India Scheme).

(5) Cartography.

3. Physical Chemistry

(1) Separation and properties of clays and clay-humus complexes from soils.

(2) Ionic exchange in soils, clays and clay minerals with reference to the formation and reclamation of saline and alkaline soils.

(3) Fixation and availability of plant nutrients in Delhi soils.

(4) Anion exchange capacity of some Indian soils.

(5) Electro-kinetic properties of alumino-silicate precipitates, clay minerals and soils in relation to formation of clay minerals.

4. Plant Chemistry

(a) Organic Chemistry

(1) Preparation of organic phosphate based on fats and oils as insecticides.

(2) Insecticides, synergists and insecticidal formulations based on indigenous materials.

(3) Development of rapid method for the estimation of pyrethrin.

(4) Biogenesis of fats during ripening of seeds.

(5) Organic mercurials as fungicides.

(6) Determination of quality of oil in small samples of oil seeds (I.C.O.C. Scheme).

(7) Development of antioxidants for edible oils and fats (I.C.O.C. Scheme).

(b) Biochemistry

(8) The quality of wheat as influenced by spraying of urea and by application of micro-element fertilizers.

(9) Nutritive value of pure strains of pulses.

(10) Paper chromatographic estimation of amino-acid in soils excreted by legumes as well as their estimation in plant protein.

- (11) Studies on the oxidative enzymes in plants.
- (12) Nitrogen metabolism in berseem as affected by phosphatic fertilizers.
- (13) Chemical composition and nutritive value of wheat (I.C.A.R. Scheme).

5. *Physics*

- (1) Comparison of spectrographic, polarographic and chemical methods of estimation of micro-elements and major elements in soil and plant products.
- (2) Micro-element uptake of different varieties of wheat and other crops.
- (3) Movement of nicotine in tobacco-tomato grafts.
- (4) Development of methods for the estimation of pyrethrins.
- (5) Study of the physical properties of plant viruses.
- (6) Study of the micro-element status of Indian soils.
- (7) Study on the micro-element uptake of plants.
- (8) Growth of wheat as influenced by the date of sowing, micro and macro-climate.
- (9) Co-ordinated scheme for the investigation of micro-nutrients (I.C.A.R. Scheme).

4. REPORT OF THE DIVISION OF ENTOMOLOGY

(Dr. E. S. Narayanan)

GENERAL

(A) *National Pusa Collection :*

The Indian forms added to the collection during the year consisted of fifty-nine species comprising 118 specimens belonging to 34 genera of family Chrysomelidae (Coleoptera) ; eighty species comprising 3,141 specimens belonging to 34 genera of various families of Hymenoptera and two specimens of *Patanga japomica* (Bol.) (Orthoptera). The exotic forms added during the year consisted of four specimens of *Caryedon fuscus* Goeze and 6 specimens of *Callosobruchus rhodesianus* Pic of family Bruchidae received from Dr. R. W. Howe, Slough, Bucks, England in exchange of Indian insects.

(B) *Donation of Insect specimens :*

Forty-six specimens of sugarcane pests and their parasites and 2 specimens of family Phycitidae (Lepidoptera) were donated to the Sugarcane Research Station, Pusa and Technical Development Establishment Laboratories, Kanpur, respectively.

(C) *Donation of insect specimens received :*

Two specimens each of *leva Indica* Bol., *L. cruciata* Bol. and *Lernia oedipodioides* Bol. of family Acridiidae (Orthoptera) were received from the Entomologist to Government of Madras, Coimbatore.

(D) *Advisory :*

(1) *Identification of insect specimens.*—227 species of insect pests, predators and parasites of Orders: Orthoptera, Isoptera, Odonata, Neuroptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera and Diptera, were identified for various State Departments of Agriculture, institutions and other individuals.

(2) *Supply of informations.*—Information relating to various insects of economic importance, their distribution, food plants and control measures and regarding predators and parasites was supplied to different institutions, scientific workers and individuals. Control measures against rats and other rodents were suggested to various institutions, and individuals. Information was also supplied on the research work done in India on *Trogoderma granaria* Everts. and *Rhynchophorus ferrugineus* Oliver to correspondents in U.S.A. and Thailand respectively. Facilities and help were given to students from various universities and colleges in the collection and consultation of literature and also in examining, comparing and studying the National Pusa Collection for their research work.

369 coloured plates of insect pests were supplied to different workers and institution. 1,086 samples of seeds imported or meant for export were examined and treated if necessary and health certificates issued. Exhibits of injurious and beneficial insects were displayed at the All India Cattle Show held at Patiala.

(E) *Delhi Intensive Cultivation Scheme :*

Under the Delhi Intensive Cultivation Scheme organized by the Ministry of Food and Agriculture, the staff of the Division continued to survey the pests of crops in the villages and to demonstrate the control methods of major pests. Control measures adopted and area

treated were 26 acres of paddy against 'Gundhi bug', $5\frac{1}{2}$ acres of sugarcane against *Pyrilla*, 5 acres of cucurbits against Red Pumpkin Beetles and 200 acres against rats. Control measures against eggs laid by locusts during the months of July and October were taken in $534\frac{1}{2}$ acres. A total area of 1,004 acres was cleared of hoppers and adults were destroyed in 3 acres.

(F) Training of students :

(1) Eleven post graduate students completed their two years course of Diploma of Associateship of the Institute. Six obtained First Division and the rest were placed in the Second Division. Six students of the 1st year and six of the 2nd year classes received training. 177 lectures, 734 practicals and 297 field work classes were held for the 1st year students. Eight general lectures were delivered to the 1st year students of other Divisions. (2) One student received training in Plant Protection course and was declared successful in the examination held after completion of the course. (3) Three students underwent training for 45 days in Plant Protection Refresher Course. (4) Three Research Fellows and five Honorary Research workers carried on investigations on different entomological problems. (5) Instruction to the three classes of the Central College of Agriculture in Zoology and Entomology was continued.

II. RESEARCH PROJECTS

Systematic Entomology

(1) *Taxonomy of Indian Vespinae* (Hymenoptera: Vespidae) :

A card catalogue of the genera and species of Indian Vespinae (Hymenoptera: Vespidae) described from the Oriental Region was completed. References on the systematics, biology, bionomics and nest instinct of all species of the world were also collected. Upto the year 1952 there are 11 genera comprising about 230 species described from the Oriental Region.

(2) *Studies on the Indian Ichneumonidae* (Hymenoptera):

Synopsis of the subfamilies Gelinae (-Cryptinae) Mesochorinae, Collyriinae, Dipilazoninae, Plectiscinae and Metopiinae was drawn up. A catalogue of the subfamily Pimplinae comprising the tribes Xoridini and Poemeniini was completed. Catalogues of other subfamilies, viz., Collyriinae, Plectiscinae, Dipilazoninae, Mesochorinae, Metopiinae and that of the tribe Banchini of subfamily Banchinae were also completed. Key to tribes of subfamily Gelinae was prepared.

(3) *Systematic studies on subfamily Otiorrhynchinae* (Coleoptera: Curculionidae) :

Studies on the genitalic structures of the male and female forms of *Mylocerus discolor* Boh., *M. 11-pustulatus* Fst. and *M. blandus* Fst. indicated that asymmetrical and symmetrical nature of median structures in males and mainly the size, shape and structure of the spermathecae in the females are useful in distinguishing the three species.

(4) *Revision of the subfamilies truxalinae and Oedipolinae* (Orthoptera: Aciridiidae) on the basis of male genitalic characters :

Permanent slide mounts of the male genital armatures of 13 species belonging to 10 genera of the subfamily Oedipodinae and 14 species belonging to 10 genera of subfamily Truxalinae were prepared and studied. Six species, viz., *Locusta migratoria* (Linn.) (Solitary

phase, *Gastrimargus transversus* Thurb. *Quiroguesia blanchardiana* Sauss., *Acrotylus humberianus* Sauss., *Heteropternis respondens* Walk., and *Acridella nasuta* Walk, were identified.

(5) *Additional Phase character of Locusta migratoria* Linn :

Biometrical studies on three specimens of *Locusta migratoria* Linn. from South India showed that the specimens were of phases *transiens* and *gregaria*. Critical examination of their external morphological characters revealed that the hind femur of these forms are completely devoid of denticles on the upper or dorsal edges whereas in the phase *solitaria* a row of denticles is always well developed in the upper or dorsal edge of the hind femur.

(6) *Studies on the male genitalia of Pachymerus gonager* F. and *Caryedon fuscus* Goetze :

A study of the male genitalia of the exotic species *Caryedon fuscus* when compared with those of the Indian species *Pachymerus gonager* showed that the two species are synonymous.

Insect Parasitology and Physiology

A. Fundamental studies :

1. *Survey of parasites and predators of important crop pests.*—Two species of Eulophid parasites belonging to the genera *Solenotus* and *Rhopalotus* and one unidentified species of a Braconid were reared on the mustard leaf miner *Phytomyza atricornis* Mg.; one unidentified braconid species on the mustard aphid predator *Spherophoria scutellaris* (Fabr.), and one unidentified tachinid on *Utetheisa pulchella* L.

2. *Fecundity, longevity and sex-ratio of Bracon gelechiae* Ashmead reared on *Corcyra* fed with synthetic diets.—Larvae of *Corcyra Stephalonica* St., were fed with the following food combinations: juar plus 10% groundnut flour, juar plus 8% yeast, juar plus 40% yeast and juar plus 20% groundnut flour. The various combinations of food had no effect on the duration of the larval development, but a marked disparity in the size of the larvae was observed when fed with rich and poor quality of food. The size of the adult moth also increased with the rich food and their eggs were significantly larger.

3. *Longevity and rate of reproduction of Trichogramma fed with various sugars and polyhydric alcohols.*—Females from the culture maintained at I.A.R.I. lived for a maximum period of 12 days when fed with sucrose, the average being 6 days. With other sugars the longevity was slightly less and with tap water the average was less than two days. The average fecundity when fed with sucrose was 46.5 eggs per female. The parasites after mating in the presence of host lived longer than those mating in the absence of host. The parasites from I.A.R.I. culture are sturdier and more vigorous than the cultures brought from Madras, but the parasites from Mysore culture was the best.

4. *Effect of temperature and humidity on the rate of development of the immature stages and on the longevity and fecundity of the parasite, Apanteles angaleti* Muesebeck.—The incubation period and the duration of instars were studied under five different temperatures (12 °C., 20 °C., 25 °C., 30 °C., and 40 °C.) and two humidities (85% and 65%). Development could not be completed at 12 °C. and 40 °C. and proper emergence did not take place at 30 °C. and 85% relative humidity.

The longevity of females fed with sugars, sucrose, glucose, maltose, fructose and also with raisins were investigated at various temperatures and humidities. Fresh raisins was found to be the best food at all temperatures and humidities.

5. *Studies on the Chalcid parasites of Pyrilla eggs : host selection by Tetrastichus pyrillae* Crawford.—It was observed that the females are able to distinguish between the parasitized and unparasitized eggs. When unparasitized host eggs are offered the parasite lays one egg in each host egg. Superparasitism was observed only in one out of 343 eggs observed. When only parasitized eggs were offered the female parasites showed restraint and no eggs were laid. It was observed that the female parasites preferred freshly laid eggs in the cleavage or blastula stage. The preference diminished with the age of the host eggs and no eggs were laid when the host embryo was fully developed.

B. Biological Control of Insect Pests :

(a) *Parasite breeding*.—During the year about $3\frac{1}{2}$ million parasites of *Trichogramma evanescens minutum* were reared on *Corcyra* eggs and $4\frac{1}{2}$ lakh specimens were supplied to the Entomologists to the Governments of Madhya Pradesh and Madhya Bharat. About 60,000 parasites were released against *Chilo zonellus* Swinh. at Karnal. The culture of *Microbracon gelechiae* Ashmead, *M. brevicornis* (Wesmael), *Apanteles angaleti* Muesebeck, *Glyptomorpha deesae* (Cameron) were maintained.

(b) *Host breeding*.—During the year about 2,50,000 *Corcyra* moths were reared and 650 c. c. of eggs were collected from them. About 400 c. c. of eggs were utilised for culture purposes and the rest used for parasite rearing.

C. Morphology and chemistry of insect egg-shell and penetration of chemicals through it :

(a) *Microbracon gelechiae* Ashmead.—The staining reactions showed that the chorion of an egg is formed of protein. The experiments with corrosive substances indicated that the chorion consists of two layers ; the outer one is non-resistant exo-chorion and the inner one is resistant endo-chorion. The former is roughly double the latter in thickness. The vitelline and fertilization membranes are composed of non-resistant protein having unsaturated lipid mixed with them. The inner side of the endo-chorion is lined with unsaturated lipid the deposition of which commences in the later stages of the ovum in the ovary and the deposition is completed after it is fertilized and laid. There is no correlation between the deposition of the lipid layer with the fertilization of the ovum, as it can be completed even in an unfertilized ovum if the latter is kept alive in Ringer's saline solution for a few hours.

(b) *Coccinella septempunctata* Linn.—The findings were similar to those described in the case of *M. gelechiae* except that the inner side of the chorion which is lined with unsaturated lipid is completed in this insect in the ovum while it is still in the ovary.

D. Apiculture :

The most unfavourable period for the honey bees, *Apis indica* Fb., was from the middle of December to middle of February, when extreme cold diminished the population and decreased the egg laying by the queens. The attack of wax moth (*Galleria mellonella* Linn.) during the year was not much. The bees became active from the third week of February and

continued to thrive upto middle of May. Swarming took place by the middle of March when there was abundant pasturage and plenty of nectar-flow. At this time supers were added to the colonies. New queen-cells were constructed and the queen also laid large number of drone-eggs. As precautionary measures against losing swarms the colonies were divided, extra queen cells removed and only two healthy queen-cells were left in each parent colony. The honey was ready for extraction by end of April. Due to drought and dust-storms, the month of June was unfavourable. The period from July onwards with the advent of monsoon and upto October was quite favourable for the colonies. A general survey of the been-pasturage of pollen-and nectar-yielding plants was continued at I.A.R.I.

Insect Ecology and Toxicology

1. Bioassay of Insecticides :

(i) *Comparative toxicity of insecticide films to the first stage larvae of some internal feeders.*—Against the first instar larvae of spotted bollworms of cotton (*Earias fabia* Stoll.) the relative toxicity of eight synthetic insecticides, taking DDT as standard, was found to be: toxaphene 0.70, chlordane 0.85, DDT 1.00, gamma BHC 1.8, aldrin 5.5, dieldrin 17.5, isodrin 19.8, endrin 103.8.

(ii) *Comparative efficacy of different insecticidal dusts in the control of desert locust* — (*Schistocerca gregaria* Forsk.).—Relative toxicity of synthetic insecticides, as dusts, was determined against 1st, 2nd, 3rd stage hoppers and adult males and females. The following order of toxicity was observed: Parathoin > dieldrin > aldrin > gamma BHC < endrin > isodrin > chlordane. Woses of gamma BHC ranging between 0.00162 to 0.089 mg. gm. body wt. were found to be sub-lethal as stomach poison to adult locust, but as injections the doses varying between 0.00146 to 0.0061 m./gm. body weight were found to be lethal. The experiments on estimating comparative toxicity by injecting the insecticides in the body cavity of the 5th stage hoppers indicated the following median lethal zones :

Insecticide	Median lethal zone (mg./gm. body wt.)
Gamma BHC	0.00145—0.00267
Aldrin	0.000555—0.000683
Endrin	0.00121—0.00136
Isodrin	0.00121—0.00288

(iii) *Comparative toxicity against other insects.*—Studies on the comparative toxicity as stomach poisons against final satge silkworms indicated the following order of toxicity: endrin > isodrin > gamma BHC > aldrin > dieldrin. With the 4th instar larvae of *Utetheisa* sp. the comparative toxicity of these insecticidal dusts as contact poisons was found to be endrin > isodrin > gamma BHC > dieldrin > aldrin. The same order of toxicity was obtained when these compounds were sprayed as emulsions of final stage larvae of *Utetheisa* sp.

(iv) *Comparative toxicity of fumigants.*—From the results so far obtained it was seen that approximately 95 mg./L. of carbon disulphide was required to obtain 100% mortality of adults of *Tribolium castaneum* Herbst. at surface and at 1 ft. and 2 ft. below the surface in

steel chambers partially filled with broken wheat, whereas approximately 119 mg./L., 303 mg./L., and 383 mg./L. of carbon tetrachloride, chlorosol and ethylene dichloride respectively were required to bring about the same results.

II. Effect of ecological factor on toxicological response (susceptibility) :

The effect of post-treatment temperature on insect susceptibility to insecticidal films was found to be as follows : (i) Insects exposed to DDT films for a short time and then kept at five different temperatures showed less mortality at 11 °C. than at 20 °C. Between 20-30 °C the mortality decreased with rise of temperature but from 30-35 °C. there was again rise in mortality with rise in temperature. (ii) Aldrin showed rise in mortality with rise in temperature, except at 30 °C. at which the LD50 was found to be a little higher than at 35 °C. Similarly gamma BHC showed higher mortality at higher temperatures, but at 35 °C. there was a decrease in mortality. (iii) In the case of chlordane, toxaphene and dieldrin there was positive temperature co-efficient throughout. (iv) With all the insecticides mortality at 11 °C. was lower than that at 20 °C.

III. Effect of temperature and humidity on the development and distribution of sugarcane stem borer (*Chilo traea infuscatellus* Snellen) :

It has been tentatively concluded that some larvae of *C. infuscatellus* enter into a physiological diapause during winter in Northern India. Development was studied at six temperatures between 12 °C. and 40 °C. Development could not be completed at either of the two extremes tried. Humidity effect was on the whole of much lower order than that of temperature.

IV. Studies on Phadka (*Hieroglyphus nigrorepletus* Bol.) :

Observations on egg pods buried in the soil in different positions showed that nymphs could not emerge from the pots in which egg pods were buried in inverted positions. The nymphs hatch but fail to find their way out. The significance of this observation lies in the fact that so far ploughing was advocated as a measure of control against this pest only so long as there was strong sun, i.e., before monsoon, but this observation establishes the utility of ploughing even after the rains have started.

V. Ecological studies on *Bagrada cruciferarum* Kirk :

Observations on the bionomics of this insect showed that it remained in soil or under the leaves under the base of the plants throughout winter and came out to feed on the foliage when the day temperature ranged between 59°-92°F. and their number decreased with the rise in temperature from 88 upwards. At the time of harvest they mass together in the harvested bundles. Maize, *Quisqualis* and *Euphorbia geniculata* were recorded as their alternative food plants. The pest migrated to cabbage after mustard was thrashed. The pest could be bred on mustard pods or seeds with water.

Besides the research projects mentioned above, investigations were started to explore the possibility of using the systemic insecticide, Pestox 3, on sugarcane against *Pyrilla* sp. and its effect on the natural enemies of *Pyrilla*. Studies on the outermost epicuticular layer in *Trogoderma granaria* Everts, adults and larvae and in the larvae of *Latheticus oryzae* Waterb., indicated the presence of cement layer protecting the underlying wax layer. Field experiment was carried out to evolve a schedule of control measure against mustard aphids. In experiments on the control of fly breeding in compost, 0.13% gamma BHC, 0.5% aldrin and endrin

dusts applied at the rate of 2 oz./sq. ft. of surface area proved to be effective in greatly reducing the emergence of flies from compost pits. Maize yellow 2 and cowpeas K 397 stored at 38° C. and relative humidity of 75% and 90% for about 3 months resulted in the viability being very adversely affected in both the seeds.

I.C.A.R. Schemes

I. Scheme for tests with DDT, 666 and allied insecticides :

Dusting against the saw fly showed that *gamma* BHC gave higher mortality than dieldrin or DDT. Spraying trial against the *Trogoderma granaria* Everts. grubs showed that aldrin had higher toxicity than Follidol E-605 and dieldrin. Emulsions of various insecticides when sprayed against larvae of *Amsacta morei* Butler showed the tentative order of toxicity as: parathion > dieldrin > *gamma* BHC > DDT > aldrin > toxophene > chlordane.

Studies on persistence showed that 0.25% and 0.5% emulsions of DDT, dieldrin, *gamma* BHC and toxaphene when sprayed on cauliflower showed a residual effect upto 32 days during November-December in all the insecticides except 0.25% toxaphene. Emulsions of 0.125% dieldrin and aldrin, 1.0% DDT and 0.25% *gamma* BHC and toxophene sprayed on knol-khol persisted for 28 days during January-February.

Studies on phytotoxicity of insecticides used as emulsions indicated that 0.5% DDT and 0.25% toxaphene sprayed on 'Gheya' (*Lagenaria siceraria*) were toxic whereas 0.25% aldrin, dieldrin and *gamma* BHC were partially so. Trials on 'Katchra' (*Cucumis pubescens*) with 0.25% toxaphene proved highly toxic ; 0.5% DDT and 0.25% toxaphene were only slightly toxic to 'karela' (*Momordica charantia*).

Maize yellow 2 and Arhar mixed treated with 10% DDT, 0.5 *gamma* BHC and 0.2% pyrethrin dusts were stored under normal conditions and the results showed that the viability of both the seeds remained unimpaired.

II. Scheme for Research on the biology and control of Termites affecting agricultural crops:

(i) *Effectiveness of insecticides in Termite control.—Wheat* : In the experiment under rain-fed conditions a minimum percentage damage of 10.463 and a maximum yield of 8.8 maunds per acre were obtained in the plots treated with dieldrin @ 15 lb. per acre. The corresponding figures in the control plots were 84.432% and 3.1 maunds per acre. Under irrigated conditions a minimum damage of 1.994% and a maximum yield of 18.4 maunds per acre were obtained in the plots treated with dieldrin @ 15 lb. per acre. The same in the control plots were 36.834% and 11.247 maunds per acre.

(ii) *Residual effect of insecticides in the control of termites infesting wheat crop.*—A mixture of technical DDT and technical BHC at the rate 15 lb. and 20 lb. per acre were persistent in the soil for more than one year as indicated by the damage percentage.

Last year's experiments on sugarcane and cotton were completed and fresh ones laid out on these crops and on groundnut. The biological studies on termites were started.

PROGRAMME OF RESEARCH WORK FOR THE YEAR 1955-56

Insect Parasitology and Physiology

1. Survey of parasites and predators of insect pests.
2. Host selection and distribution of progeny in *Microbracon chinensis* Szep. and *M. brevicornis* (Wesmael).
3. Studies in coefficient of parasite efficiency of some parasites of Indian crop pests.
4. Biological control of pink bollworm and potato tuber moth.
5. Morphology and chemistry of insect egg shell and penetration of chemicals through it.
6. Studies of chalcid egg parasites of *Pyrilla*.
7. Role and evaluation of some coccinellids (Coleoptera) and syrphids (Diptera) in the control of aphids of economic importance.
8. Effects of nutrition of host on fecundity, longevity and sex-ratio of *Microbracon gelechiae* Ashm.
9. Field experiments in the biological control of *Chilo zonellus* Swin.
10. Sensory physiology and physiological behaviour of *Chaetodacus* sp.

Insect Ecology & Toxicology

11. Studies on the development and distribution of insects under different ecological conditions.
12. Studies on population determination and assessment of damage.
13. Effect of chemical control on the biological balance in cultivated crops.
14. Factors responsible for variation in insect's susceptibility and insecticidal toxicity.
15. Bioassay of insecticides.
16. Toxicological and ecological studies on locust.
17. Studies on the effect of DDT and some fumigants on insect infestation of stored grains and viability of seeds.
18. Field and laboratory tests with pyrethrum against important crop and stored grain pests.
19. Laboratory tests on the chemical control of locusts in flight and situ.
20. Oviposition responses by desert locust.
21. Phenological observations on crop pests.
22. On the control of fly breeding in compost.
23. Use of repellents against locust hoppers and adults.
24. I.C.A.R. Termite Research Scheme.
25. Unit for locust research for the Directorate of Plant Protection.

Systematic Entomology

26. Taxonomy of Indian Curculionidae (Coleoptera).
27. Taxonomy of Indian Vespinae (Hymenoptera : Vespidae).
28. Taxonomy of Indian Aeschnidae (Odonata).
29. Studies on Indian Ichneumonidae (Hymenoptera).

5. REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(R. S. Vasudeva)

RESEARCH

A. Section of Plant Pathology

1. Wheat :

(a) *Rust* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn., *P. triticea* Erikss., and *P. glumarum* (Schmidt.) Erikss. and Henn.] : Four hundred and forty-five rust samples (442 from wheat and 3 from wild grasses), collected from different parts of the country, were analysed for physiologic race study and races 15, 21, 24, 34, 40, 42 and 122 of black rust, races 10, 11, 20, 26, 63, 77 (new race), 106, 107 and 108 of brown rust and races 13, 19, 20, 31, A, D and F of yellow rust were obtained. The new race 77 of *Puccinia triticea*, which infected the differential varieties Mediterranean and Democrat, hitherto resistant to all the other races of this rust, was collected on the wheat varieties Mediterranean, N.P. 798, N.P. 809, Fund and Botla and was found to be widely distributed in Punjab, Bombay, Bihar and U.P. The virulent race 122 of black rust, first reported last year, was picked up from Kulu Valley in Punjab and Delhi State. Races 21, 40 and 42 of black rust, 10, 20 and 63 of brown rust and A and 19 of yellow rust were predominant and widely distributed throughout the country. Two mutants from race 194 of black rust were obtained which differed from the parent race in colour and size of uredospores as also in incubation period, but not in pathogenicity.

A search for collateral hosts in the hills of Punjab, Bombay, Himachal Pradesh, Mysore and Madras was continued. *Muchlenbergia hugelii* Trin., a perennial grass growing wild in the Upper Simla hills, was found to be naturally infected with the yellow rust and subsequently established to be a collateral host by cross-inoculation. Further evidence of oversummering of all the three rusts in the Nilgiris, Mysore and adjoining tracts, and higher altitudes of Simla and Kulu hills was obtained.

Study of alternate hosts so far has given no indication that the aecidial stage, collected on *Berberis* spp. from Simla and Lahaul Valley, is connected with the black rust. The aecidial stage on *Berberis jaeschkeana* from Lahaul Valley, however, appeared to be connected with a local grass rust.

In aerobiological studies, aeroscope slides from 16 rust nurseries exposed during 1953-54 and 29 during 1954-55 were examined. From the first lot, 8 cases of spore showers for the outbreak of black rust, 1 for brown rust and 2 for yellow rust were found to be of significance, i.e., the spore showers took place 7-10 days before the reported dates of rust appearance at the respective localities. In the latter case, spore showers of significance were encountered in 9 cases for black rust, 6 for brown rust and 7 for yellow rust.

In the seedling resistance trials, about 20,500 plants of various wheat varieties and cultures were tested against individual races of black, brown and yellow rusts. Wheat varieties E. 871, E. 1913, E. 1951 and E. 2025 proved resistant to all the races of black rust except race 122; wheat varieties E. 871 and E. 1844 reacted as resistant to all the races of brown rust except race 108; and wheat varieties N.P. 723, N.P. 785, N.P. 786, N.P. 814, H.D. (52)-30 and E. 1844 were found to be resistant to all the races of yellow rust except races F and H. It might, however, be mentioned that the seedling resistance tests with race 108 of brown rust

and races F and H of yellow rust could not be carried out under optimal conditions and are being repeated. In addition, 127 wheat varieties were tested against mixture of races of black rust, 134 against brown rust, and 114 against yellow rust. Wheat varieties E. 1906, E. 2564, W.R. 163, W.R. 169, W.R. 199, W.R. 200, W.R. 203, W.R. 215, W.R. 216 and W 375/S. 77 were found to be resistant to black rust; E. 1065, E. 1770, E. 1847, E. 1882, E. 1912, E. 2143, E. 2144, E. 2285, E. 2446, E. 2547, E. 2548, E. 2562, W.R. 160 W.R. 187 and 6 Rajasthan varieties to brown rust; and E. 1770, E. 1771, E. 1851, E. 1878, E. 2067, E. 2546, Hybrid 46, W.R. 154, W.R. 160, 9 selections from fixed hybrids and 2 Punjab selections to yellow rust.

In the adult resistance tests, about 110,000 plants were examined in the field for their resistance after exposure to heavy infection (artificially created) of all the races of black, brown and yellow rusts. More than 1,500 resistant varieties, crosses or plants have been selected for further study.

In the Agronomic-cum-Rust experiments, heavy application of nitrogen (60 lbs. per acre) or three irrigations showed increased rust incidence as compared to the control.

In the fungicidal spraying experiments, due to a very low natural incidence of rust infection this year, it was not possible to judge the efficacy of the various fungicides tried for the control of rusts. It might, however, be mentioned that the yields obtained from the treated plots were higher than the untreated controls. This point is being further investigated.

(b) *Loose smut* [*Ustilago tritici* (Pers.) Rostr.]: Out of 86 wheat varieties tested for their resistance to the disease at Delhi and Simla, 55 remained free from infection and may be considered as promising from the point of view of loose smut resistance. For physiologic race study, inoculations were made on several wheat varieties with 6 new and 2 old collections of *Ustilago tritici* for the selection of suitable differentials, as some of the standard differentials do not flower under local conditions.

The wheat variety N.P. 775, artificially inoculated with the loose smut fungus and given solar heat treatment, remained completely free from infection, whereas the untreated seed showed 23.5 per cent infection. Samples from the bulk wheat (N.P. 775 and N.P. 781) treated likewise showed 0 to 0.39 per cent infection as against 2.1 to 4.6 per cent in the control, thus confirming that the method is really effective for the control of the disease.

(c) *Bunt* [*Tilletia foetida* (Wallr.) Liro and *Neovossia indica* (Mitra) Mundkur]: In the varietal resistance tests against the European Bunt (*Tilletia foetida*), the wheat varieties N.P. 785 and N.P. 786 showed 11.7 and 7.5 per cent infection, respectively, as compared to the remaining 29 varieties where the infection ranged from 50.9 to 93.9 per cent. Thus, these two varieties (N.P. 785 and N.P. 786) may be considered as promising from the point of view of bunt resistance.

The spores of Karnal Bunt (*Neovossia indica*), collected from different States during the month of April, germinated from September onwards, indicating thereby that a resting period was necessary before germination. It was also observed that better germination was obtained in Farm Yard Manure extract or in a nutrient solution containing nitrogen source. Germination up to 80 per cent could thus be obtained in 10 days' time at 15-22°C. All the samples, collected from different localities and wheat varieties, showed almost the same percentage of germination. Field and pot experiments conducted at Delhi and Karnal to determine the mode of infection showed that the disease was air-borne and a case of floral infection, as no infection could be obtained through infested seed or soil, whereas 48 per

cent infection was obtained at Delhi and 88 per cent at Karnal by inoculating wheat ears in the boot stage with spore or sporidial suspension by the hypodermic syringe method. Infection was also obtained by Moore's Partial Vacuum method and by spraying the artificially lodged wheat plants with sporidial suspension.

2. Barley :

(a) *Rust* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn. and *P. glumarum*. (Schmidt.) Erikss. and Henn.] : Nine rust collections of barley, obtained from different parts of the country, were analysed for physiologic forms which yielded races 21, 34 and 42 of black rust and race G of yellow rust. Nine barley varieties were tested with a mixture of all the races of black and yellow rusts in the seedling stage, but none proved to be resistant. In the adult resistance tests, however, against a complex mixture of all the races of black and yellow rusts, 54 barley cultures, out of 141 tested, were found to be resistant to yellow rust.

Leaf rust of barley (*Puccinia hordei* Oth.), reported to be rare in India, was isolated from a few rust collections from Delhi, U.P. and Nilgiris. Studies on physiologic specialization of the fungus were in progress.

(b) *Loose smut* [*Ustilago nuda* (Jens.) Rostr.] : Varietal resistance tests were undertaken and, in this connection, 28 barley varieties were artificially inoculated in the blossom stage. Necessary cross-inoculation tests have also been carried out with the wheat and barley loose smut organisms to determine their identity.

3. Sugarcane :

(a) *Red Rot* (*Colletotrichum falcatum* Went) : During the year under report, red rot was recorded in an epidemic form from certain localised areas of Hoshiarpur, Jullundur, Ambala and Jagadhari in Punjab and the cane varieties Co. 312, Co. J. 33 and Co. L. 29 were chiefly found affected. Jagadhari Cane Development area, which had been the pocket of red rot infection in the previous years, was found to be free from the disease due to the replacement of the effected variety Co. 312 with moderately resistant varieties Co. 421, Co. 453 and Co. L. 9. Isolations from the diseased canes, obtained from the epidemic areas, yielded light type cultures of *C. falcatum*.

In the Physiologic Forms studies, twenty-eight isolates of *C. falcatum*, including those received from Shahjahanpur (affecting Co. 356), U.P. (affecting Co. 453 and Co. 312), Bihar (affecting Co. 453) and Punjab (affecting Co. 312) were tested on the ten standard cane varieties (Co. 213, 223, 299, 312, 313, 331, 356, 419, 421 and 445), consisting of different genetic composition and possessing varying degree of resistance to red rot, but no evidence of physiologic specialization within the fungus was obtained. The light type isolates of *C. falcatum* as usual were found to be more virulent than the dark ones.

In the varietal resistance tests, 195 cane varieties were tested by the plug method with *C. falcatum* isolate No. 244. No variety was found to be resistant ; 104 varieties behaved as moderately resistant and the remaining 91 as susceptible. In addition, 102 cane varieties were tested for their resistance to the red rot infection through the nodal regions. Only two varieties reacted as moderately resistant and the rest as susceptible.

In order to study the effect of the mixed inocula on red rot infection, different combinations of dark and light type, light and light type, and dark and dark type *C. falcatum* isolates were tried on the ten standard cane varieties. The mixture of light and dark type isolates

gave more infection in most of the cane varieties than the individual strains or other combinations of these isolates. It was also observed that there was no significant increase in red rot infection when the dose of the inoculum was doubled.

In the experiment to study the relative resistance of the plant and ratoon crops to red rot, it was confirmed that the ratoon crop was slightly more susceptible than the plant crop.

Experiments to study the varietal resistance to red rot in sugarcane were continued at Coimbatore in collaboration with the Director, Sugarcane Breeding Institute. Out of 235 Final Test Plot seedlings (P and G numbers) and 10 standard cane varieties tested, 49 seedlings and 3 cane varieties reacted as resistant. One hundred and seventy-six seedlings in the Preliminary Test Plot and 43 variants of *Saccharum spontaneum* were also tested. *Erianthus hookeri*, *E. arundinaceus* and *Narenga* (S.E.S. 201) reacted as resistant, while *Sclerostachya* (S.E.S. 216) behaved as moderately resistant. In addition, 4 hybrids of *S. officinarum* X *Narenga* and 2 of *S. officinarum* X *Sclerostachya* reacted as moderately resistant, while *S. robustum* X *Sclerostachya* hybrid was found to be susceptible.

Varietal resistance tests with 30 locally important and promising cane varieties of Punjab were carried out at Jullundur and Jagadhari, of which 22 proved as moderately resistant. The progress of infection in the inoculated canes was found to be slightly greater under Jagadhari conditions.

(b) *Smut (Ustilago scitaminea* Syd.) : In the varietal resistance tests, 72 cane varieties at Delhi and 88 at Karnal were inoculated with smut spore suspension and then planted in the field for observation. At Delhi, 11 varieties showed less than 5 per cent infection, 13 showed 5-15% infection, 14 gave 15-30% infection and the remaining 34 varieties showed 30-100% infection. The corresponding figures for the Karnal experiment were 25, 23, 13, and 27. Thirty-six varieties, namely, P. 4628, S.G. 227/9, B.O. 9 and Co. 716, 760, 761, 766, 776, 787, 820, 821, 822, 823, 824, 830, 832, 833, 856, 862, 876, 890, 893, 917, 923, 930, 947, 950, 960, 973, 978, 980, 990, 994, 995, 999, and 1,000, which showed less than 5% infection, may be considered as resistant. Of these, 13 varieties had reacted as resistant in the previous tests also.

4. Linseed :

Rust [Melampsora lini (Pers.) Lev.] : Fifty samples of linseed rust, collected from different parts of the country, were analysed which yielded Indian races 1, 2, 3, 4 and 5 of *Melampsora lini*. The new race 5, first observed from Punjab collections last year, differed from the already existing four races in its reaction on the auxiliary differentials Argentine Selection C.I. 705-1, Bison and Koto. Studies on the collateral hosts were continued and *Linum mysorens*, which grows wild in the hills of India, was established as new host for the rust. In the varietal resistance tests with 134 linseed varieties in the seedling and adult stages, 95 varieties proved to be resistant.

5. Pigeonpea :

Wilt (Fusarium udum Butler) : Twenty pigeonpea varieties, received from the Division of Botany, were tested for wilt resistance. Varieties N.P. 41 and P 3-2 in pot experiments and N.P. 41, C. 36, C. 15 W.E., F. 52, P. 18-2, P. 131-1, P. 253A 2, P. 298 A and Brazil in field trial did not develop wilt. The variety N.P. 41 has been consistently found to be resistant both in pots and under field conditions for the last 11 years.

6. Bajra :

Green-ear disease [*Sclerospora graminicola* (Sacc.) Schroet.]: Oospore material of *Sclerospora graminicola*, exposed for weathering since October, 1953, gave 25-27 per cent infection, whereas similar material stored in the laboratory showed only one per cent infection. The exposed material also showed better spore germination than the one stored under laboratory conditions. Material from Bikaner, Jodhpur and Delhi gave 42, 26 and 8.5 per cent infection, respectively. Oospore-infested soil, exposed for weathering since 1951, gave infection again this year without the addition of any fresh inoculum, thus indicating the persistence of infection in the soil and germination of oospores in small numbers at varying intervals. *Bajra* seed, collected from heavily infected fields in Bikaner and Jodhpur, gave 8 and 12 per cent infection, respectively, showing thereby that seed may also act as a carrier of the disease.

7. Antibiosis :

The *Alternaria solani* assay method for the antibiotic from *Bacillus subtilis* was further investigated in detail and standardized. The presence of magnesium sulphate in the fermentation broth was found to be the most important factor for the growth of the bacterium and antibiotic production. Solvent extraction with n-butanol and subsequent chromatography on alumina yielded a crystalline product with high antibiotic activity.

Investigations into the biological spectrum of the antibiotic showed that it was chiefly antifungal and antiviral, but not antibacterial. Among the test fungi, 12 showed "bulb" formation and 5 of these showed marked inhibition of spore germination and subsequent growth. The bulb-forming activity was confined to fungi which are known to have chitinous cell walls. The activity of the substance was greater in liquid cultures than in agar media.

The growth of *Xanthomonas punicea* sp. nov., causing leaf spot of pomegranate, was inhibited by small concentrations of Dihydroxystreptomycin (8 to 40 micrograms per ml.), but the organism in due course appeared to have developed tolerance to the antibiotic.

In preliminary tests seven antibiotics, namely, Griseofulvin, Gliotoxin, Citrinin, Dihydroxystreptomycin, Aureomycin, Terramycin and the one from *Bacillus subtilis*, did not prevent infection of the wheat seedlings by *P. graminis tritici*.

8. Physiology of Fungi :

The importance of the interrelationship between the carbohydrate and vitamin nutrition for growth and sporulation of *Lophotrichus ampulus* Benj. was established. Suppression of sporulation by glucose was found to be accompanied by greater accumulation of fat in the mycelium in the presence of this sugar. Studies on the mechanism underlying sporulation indicated that in this fungus sucrose was directly converted into glucose-1-phosphate.

Exobasidium vexans, the casual organism of blister blight of tea, was grown on a synthetic medium containing four B-vitamins (Thiamine, Riboflavin, Nicotinic acid and Pyridoxin). Work on the physiology of some less specialized parasitic fungi e.g., *Fusarium solani* and *Botrytis allii* was continued.

Studies on plant tissue culture were in progress. Potato callus cultures were established on nutrient agar media with the object of culturing obligate parasites on them.

9. Fungicides :

Replicated field experiments were conducted to determine the relative efficacy of some common seed-dressing fungicides on the emergence, stand and yield of *bajra*, maize, barley and wheat. In general, different seed dressings showed beneficial effect in the case of maize and *bajra* and increased emergence and yield of the two crops. Ceresan M [N. (ethyl mercury)-P-toluene/sulfonanilide] in the case of maize and Agrosan GN (tolyl mercury acetate) in the case of *bajra* were found to be comparatively more effective. In the case of wheat, there was slight increase in germination in all the seed-dressing treatments, but a slight increase in grain yield was observed only in the case of Spergon (tetrachloro-p-benzoquinone) and Ceresan M fungicides. No appreciable effect of any of the fungicides tested on barley was observed.

The reported efficacy of "Aretan" (2-methoxyethyl-mercury chloride) was tested. The cane setts (seed cuttings) were treated with two concentrations of the fungicide (1 lb. in 10 gallons and 1 lb. in 20 gallons of water) at the time of planting. Ten per cent increase in germination and about 15% increase in yield over the controls in the treatment where the setts were steeped for 10 minutes in the lower concentration of the fungicide was obtained. In the case of instantaneous dip of the setts, an increase of 10% in germination and 6% in yield was observed with the higher concentration of the fungicide.

10. Bacterial diseases of plants :

(a) "Tundu" disease of wheat [*Corynebacterium tritici* (Hutchinson) Bergey *et al*]: The wheat pathogen, *Corynebacterium tritici*, is found to be a strain of *C. rathayi* which produces similar symptoms on *Dactylis glomerata* in other countries. It has been confirmed that there exists between this organism (*C. tritici*) and the nematode (*Anguina tritici*) an obligate etiological relationship as the disease can only be produced when wheat seedlings are grown in soil infested both with the bacterium and the nematode *i.e.*, by the use of nematode galls mixed with wheat seed. It has, however, not so far been possible to isolate the pathogen from the nematode galls or show its presence in them by histological technique. It has been shown that the two bacteria, namely, a white Gram-negative and a yellow Gram-negative, isolated from the diseased wheat ears, do not play any role in the development of the disease whether used singly or in combination with *C. tritici*.

(b) Brown rot of Potato (*Pseudomonas solanacearum* Erw. Smith): Study of large number of collections of the affected tubers from different potato growing tracts of the country showed that, in addition to *P. solanacearum*, another organism *P. solanacearum* var. *asiatica*, which differs from the former in producing acid in cream and litmus milk, is also widely prevalent in the country, particularly in Madras, Mysore, Bengal, Bihar and Assam.

(c) Leaf spot disease of pomegranate (*Xanthomonas punicae* sp. nov.): Detailed cultural studies of the pathogen have shown that it has so far not been recorded and has, therefore, been named *Xanthomonas punicae* sp. nov. The disease is favoured by high temperature and low humidity as infection could only be obtained during the second fortnight of March and the months of April, May and June. Furthermore, the pathogen was found to survive in dead, fallen leaves during the off-season (December to March) and caused fresh infections when the plants put forth new growth.

11. Miscellaneous :

(a) *Deficiency disease of Guava*.—A serious disease of guava, characterised by interveinal chlorosis, extreme reduction in leaf size, suppression of growth and die-back of leaders, was first reported from Pushkar Valley (Ajmer) in 1949. The diseased shoots did not bear any flowers, and fruits, if any, dried up and cracked. The cultivators were found abandoning guava cultivation due to the seriousness of the disease which has been estimated to cause an annual loss of about 6 to 7 lakhs of rupees in Pushkar Valley alone.

Repeated tests conducted in the Division since 1949 showed that the disease was not of virus origin and also that no pathogenic organism was associated with it. Furthermore, 20 diseased guava plants, collected from Pushkar Valley and transplanted in Delhi soil, recovered from the disease, indicating thereby that the diseased condition might be due to nutritional deficiency.

Experiments were, therefore, conducted during the year under report in the affected orchards in 3 villages of Ajmer to determine if foliage sprays of zinc sulphate, manganese sulphate, ferrous sulphate, Bordeaux mixture or zinc and copper in various combinations could cure the disorder. In all, 556 guava trees of different ages (2-13 years) in 8 different orchards were sprayed and, in all the cases, zinc sulphate proved to be very effective. The diseased shoots after treatment started putting out normal healthy leaves and flowers on new growth and forming fruits. Younger trees required 2-3 sprays, while to the older ones 4-5 sprays had to be given. The spray consisted of zinc sulphate 1.0 lb., hydrated lime 0.7 lb. and water 16 gallons. Further work is in progress.

(b) *Macrophoma leaf spot of mango*.—Comparative cultural, morphological and pathogenicity studies of the parent culture and its mutant showed that the mutant strain produced mature pycnidia abundantly on most of the synthetic media within 7 to 10 days, whereas the parent culture took about 40 days to produce a few mature pycnidia on some of the media ; further, that the spores of the mutant strain were slightly smaller and that the mutant appeared to be more virulent than the parent as it produced pycnidia on all the hosts infected. There was, however, no difference in their host range as both the isolates successfully infected *Mangifera indica*, *Ficus carica*, *Vitis vinifera*, *Eugenia jambolana* and *Eriobotrya japonica*.

The mutant strain was found to produce a perithecial stage after about 30 days' growth on mango-leaf-extract agar at 25-30°C., as also on a basal medium containing no nitrogen source. The connection between the ascigerous and conidial stages was established both culturally and pathologically. The single-ascospore cultures yielded the conidial stage, resembling the mutant strain, and it infected all the five hosts attacked by the *Macrophoma* sp. and its mutant. The morphological characters of perithecia, asci and ascospores indicate tentatively that the fungus belongs to the genus *Phomatospora* Sacc.

(c) *Cultivation of edible mushrooms under Delhi conditions*.—Preliminary investigations on the preparation of spawns and cultivation of edible mushrooms were undertaken on a laboratory scale between June to November 1954. Two cultures of paddy straw mushroom (*Volvaria diplasia*), obtained from Calcutta and Coimbatore, were used in this study. The two strains differed from one another in their mushroom-producing capacity as also in the colour of the mushrooms produced by them. The Calcutta strain produced mushrooms in.

clusters of 10-15 heads and were milk white in early stages, whereas the Coimbatore strain developed fructifications singly or in clusters of two which were slightly greyish from the very beginning.

Typical paddy straw mushrooms were successfully produced in paddy straw beds laid down in glazed cages during the months of July, August and early September. Efforts to grow this mushroom before monsoon during June and after monsoon during October and later remained unsuccessful. A temperature of 32-36 C. and humidity to saturation point were found to be the most suitable conditions for the production of the mushroom. Excessive or under watering of the beds, high fluctuation of temperature and exposure to wind retarded or suppressed mushroom production.

B. Section of Plant Viruses

12. Tomato :

(a) *Leaf curl*.—Search for material resistant to leaf curl with a view to evolve resistant varieties was continued and, in this connection, five wild species of *Lycopersicon*, namely, *L. peruvianum*, *L. pimpinellifolium*, *L. pississi*, *L. glandulosum* and *L. hirsutum* were tested for the third year for their resistance to the disease both by grafting and through viruliferous white-flies. None of the species was found to be immune to the disease. *L. peruvianum*, however, continued to show high degree of resistance (4.2% infection through viruliferous white-flies) and may be successfully used for breeding work.

(b) *Necrosis*.—Host range studies by grafting and insect transmission tests with *Aphis gossypii* and *Myzus persicae* were continued. The disease was transmitted to potato varieties *Up-to-date*, *President*, *Arran Victory* and *British Queen* by grafting, but not to *President*, *Arran Victory* and *Epicure* through sap inoculation. *Aphis gossypii* and *Myzus persicae* did not prove to be vectors of the virus.

(c) "Smalling" disease.—A serious disease, causing "Smalling" and severe mottling of tomato leaves observed in Kandaghat area of Simla Hills, was investigated. The virus could not be transmitted by sap inoculation. It was, however, transmitted by grafting to tomato, tobacco, brinjal, *Datura stramonium*, *Solanum nodiflorum*, *Nicotiana rustica*, *N. glutinosa*, *N. affinis*, *Petunia hybrida* and *Nicandra physaloides*. The white-flies, collected locally and identified as *Bemisia* sp., failed to transmit the disease to *Lycopersicon esculentum*, *Datura stramonium* and *Zinnia elegans*.

13. Bhindi :

Yellow-vein mosaic.—A search for collateral hosts in nature was continued. *Croton sparciflorus* and *Ageratum conyzoides* were found to be the additional hosts of the virus. *Abelmoschus manihot* var. *pungens* did not get infected even when it was fed upon by 50 viruliferous white-flies at the time. *Zinnia elegans* was, however, successfully infected in artificial inoculations. Testing of wild species of *Hibiscus* and *bhindi* varieties for their resistance to the disease was continued.

14. Chilli :

(a) *Leaf curl*.—A severe type of leaf curl disease of chilli, characterised by curling and puckering of leaves, suppression of flowers and stunting of axillary shoots observed in Pushkar Valley, Ajmer, has been shown to be caused by tobacco leaf curl virus (*Nicotiana Virus 10*).

(b) *Mosaic*.—Insect transmission tests were continued and *Aphis gossypii* was established to be the vector.

15. Brinjal :

(a) *Mosaic*.—In the varietal resistance tests, *brinjal* varieties (3-4-5-7), (4-4-6-9), *American purple* and *Florida Market* were found to be susceptible. The virus could not be transmitted to *Hyoscyamus niger*, *Carica papaya*, *Datura stramonium* and *Solanum torvum*. It was experimentally proved that the mosaic virus was not transmitted through seed.

Repeated transmission tests of Delhi strain of the virus with *Empoasca devastans* gave negative results, thus confirming that it is not a vector of the virus as reported earlier.

(b) "Little-leaf" disease.—Host range studies of the virus with several plant species, namely, *Phlox drummondii*, *Delphinium ajacis*, *Calendula officinales*, *Cellistephus hortensis*, *Viola tricolor*, *Zinnia elegans*, *Nicotiana* spp., *Vinca rosea*, *Lathyrus odoratus*, *Chrysanthemum indicum* and *Linaria vulgaris* showed that only *Vinca rosea* developed typical little-leaf symptoms.

16. Sesamum :

Phyllody.—The jassid, *Deltocephalus* sp., was established to be a vector of the virus. Five sesamum varieties and *Sesamum occidentale*, received from the Botany division were found to be susceptible when tested by grafting *Sesamum indicum* and *S. radiatum* were observed to be severely affected with the disease under field conditions. In host range studies, the virus was transmitted to *Crotalaria juncea* and *Brassica campestris* var. *toria* through the agency of the vector, *Deltocephalus* sp., producing typical phyllody symptoms. Preliminary experiments showed that the disease was not seed-transmissible.

17. Pumpkin :

Yellow-vein mosaic.—Host-range studies of the virus through the agency of viruliferous white-flies were continued. The virus was transmitted to *Lagenaria siceraria* and *Cucumis sativus*, but not to *Datura stramonium*, *Lycopersicon esculentum*, *Nicandra physaloides*, *Xanthium strumarium*, *Conchus* spp., *Zinnia elegans*, *Desmodium laxiflorum*, *Althea rosea*, *Euphorbia geniculata*, *Cucumis melo*, *Cucurbita pepo*, *Citrullus vulgaris*, *Ipomoea purpurea*, *Spinacea oleracea*, *Brassica rapa* and *Zea mays*.

18. Papaya :

(a) *Mosaic*.—Search for natural occurrence of the virus in other common plant species was continued. Mosaic infected plants of *Cucurbita maxima*, *Datura fastuosa*, *Lagenaria siceraria* and *Vigna sinensis* from the neighbourhood of affected papaya plants were tested, but did not reveal the presence of the papaya mosaic virus.

Cutting back of the affected plants, considered effective for the control of Papaya leaf curl in Hawaii, has not given any hopeful results, as the virus appears to move very rapidly downward into the plant after inoculation.

It has been shown that papaya leaf curl is caused by tobacco leaf curl virus (*Nicotiana Virus 10*).

19. Cotton :

"Small-leaf" disease.—Testing of commercial varieties of cotton for their resistance to the disease by grafting was continued. Uppam (h 2919), N.M.D. and two Indo-American interspecific hybrids (170 x CO. 2 and 134 x CO. 2) were found to be susceptible, whereas Tree Cotton proved resistant.

20. Banana :

Mosaic.—Studies on mode of transmission, varietal resistance, host-range and insect-vector were continued. The virus was again transmitted to *Cucumis sativus* by juice inoculation, but not to banana, *Lagenaria siceraria* and *Cucurbita maxima*. It was readily transmissible to banana by *Aphis gossypii*. Seven banana varieties (*Basri*, *Kadabali*, *Kadgi Velchi*, *Lal Velchi*, *Mutheli*, *Safeda* and *Metli*), tested for their resistance to the disease, were found to be susceptible. In host-range studies, the virus could not be transmitted to *Cucumis sativus*, *Citrullus vulgaris*, *C. fistulosus*, *Lagenaria siceraria*, *Momordica charantia* and *Cucurbita maxima* by means of viruliferous aphids.

A new method of feeding aphids on diseased banana leaves was devised. A young diseased leaf was rolled in the form of a tube of about 1 inch diameter, one end of which was closed by a paper clip. The aphids were liberated inside the tube from the other end which was then closed likewise. The cage was rested in a horizontal position and the aphids allowed to feed for the desired length of time after which they were transferred to healthy test plants.

21. Sugarcane :

(a) Mosaic.—The virus was successfully transmitted to sugarcane varieties Co. 313 and *Surkha Saharanpuri* by means of *Aphis maidis*, but not to the other three cane varieties (Co. 213, Co. 312 and Co. 798) tested. A species of *Toxoptera* was established as an additional vector of the virus.

(b) "Grassy-shoot" disease.—This is a new disease affecting Co. 419 in Bombay State and is characterised by the production of excessive tillering which may be accompanied by chlorosis, resulting in appreciable reduction in cane and leaf size. The affected stool may throw up a few thin, weak and stunted tillers from the base and, at an advanced stage of cane growth, the dormant buds may also sprout and grow into slender shoots giving the clumps a bushy appearance. Usually the affected clumps have only grassy shoots. The disease is more serious in the ratoon crop. In some cases pronounced twisting of the cane tops and sprouting of the normally dormant buds has been observed.

Work is in progress to determine the nature of the disease and preliminary tests indicate that the disease may be of virus origin.

22. Maize:

Mosaic.—In host range studies, the virus was transmitted to *Brachiaria ramosa* and *Digitaria bifasciculata*, but not to the sugarcane variety *Surkha Saharanpuri*. *Phalaris minor*, a common weed, was found to carry the virus symptomlessly. An unidentified species of *Toxoptera*, which transmitted sugarcane mosaic virus, was found to be an additional vector of this virus. Its relationship with the sugarcane mosaic virus was being studied by cross-immunity tests.

23. *Sunn-hemp* :

Mosaic.—Host-range studies with the cultures obtained from Poona and Delhi material of the virus were continued. Both the cultures were found to infect *Nicotiana glutinosa*, *Datura inoxia*, *Phaseolus vulgaris*, *Vigna sinensis* var. *New Era* and *V. cylindrica*, but neither could be transmitted to *Nicotiana tabacum*, *Phaseolus lunatus*, *Datura fastuosa* and *Ipomoea muricata*, thus indicating that both the cultures are identical.

24. *Sarson* :

Mosaic.—Further investigations on host-range of the virus were conducted. The virus could not be transmitted by sap inoculation to *Brassica oleracea* var. *capitata*, *B. oleracea* var. *botrytis*, *B. oleracea* var. *gemmifera*, *Iberis* sp., *Cheiranthus cheiri*, *C. kewensis*, *Mathiola incana*, *M. bicornis* and *Hesperis matronalis*. It could not be transmitted even by grafting to cabbage (*B. oleracea* var. *capitata*) and stock (*Mathiola incana*). The thermal-inactivation and dilution-end points of the virus were found to lie between 60-70° C. and 1:1,000—1:10,000, respectively. The aphid, *Macrosiphum granarium* Kirby, was found to be the vector of the virus.

25. *Development of new strains, serological relationship and cross-immunity studies* :

Further investigation on mutation in *Cucumis* Virus 2C, which is responsible for mosaic disease of bottle gourd (*Lagenaria siceraria* Standl), were continued. Effect of different coloured lights on mutation was being studied.

Cross-protection experiments with the *Dolichos* Enation mosaic (DEM) and Tobacco mosaic (TM) viruses on tobacco plants were in progress. The results obtained showed that neither the DEM nor the TM virus gave any protection to tobacco plants against infection with the other even at intervals of 12 or 18 days between the two inoculations. Similar studies with *Cucumis* Virus 2C and its mutant strain are in progress.

Investigations on the properties and identification of virus strains involved in 8 cultures established from mosaic-affected tobacco and tomato plants (seven from tobacco and one from tomato) were continued. The components other than *Nicotiana* Virus I in the cultures showing mixed infection were separated out through the differential hosts. One such component, which produced systemic infection in *Nicotiana glutinosa*, was studied in detail. The virus was found to produce systemic infection by sap inoculation in *Nicotiana tabacum* var. *White Burley*, *N. glutinosa*, *N. grandiflora*, *N. affinis*, *N. longiflora*, *Solanum nigrum*, *Capsicum frutescens* var. *longum*, *Petunia hybrida*, *Datura alba* and *D. inoxia*, but could not be transmitted to *Cucumis sativus*, *Phaseolus vulgaris* and *Gomphrena globosa*.

26. *Isolation and purification of plant viruses and study of their properties* :

Attempts were being made to isolate and purify the *Crotalaria* mosaic virus and *Dolichos* Enation mosaic virus by different techniques. However, only partially purified virus material could be obtained in both the cases. Further purification is in progress.

27. Virus-vector relationship:

It was found that the white-fly was capable of carrying three different viruses (Yellow vein mosaic viruses of pumpkin and *bhindi* and mosaic of lima bean) simultaneously for 6-days. The virus causing "Katte" disease of cardamom, when secured by the aphids from *Amomum* plants, did not persist in the vector and got exhausted after the first feed on healthy cardamom plants. Banana mosaic virus was secured by the aphids (*Aphis gossypii*) from the diseased plants within 30 minutes. In the case of "Little-leaf" of *brinjal*, the incubation period of the virus was found to be 8 days during summer and 31 days during winter months. The viruliferous jassids (*Eutettix phycitis*) transmitted the virus to healthy test plants in a feeding period of one hour, and they retained the virus throughout their lives. Third and fourth instar nymphs also transmitted the virus to healthy plants.

28. Control of virus diseases :

Work on the control of "Katte" disease of cardamom in Bombay State by eradication of diseased plants and rehabilitating the gardens by transplanting disease-free seedlings was continued. The present position of the campaign is that gardens, which are away from the diseased area and in which all the diseased bushes were destroyed and replaced by healthy plants, continue to be disease-free for the last 7 years. In North Kanara, there are several pockets which are still disease-free because of natural barriers.

29. General :

Studies on the inhibition of a strain of potato virus-X were being carried out. When the leaves of *Gomphrena globosa*, after inoculation with potato virus-X (1:10), were exposed immediately to ultra-violet light for 5, 10 and 15 minutes, an inhibition of 60, 70 and 92 per cent, respectively, was obtained as judged by the number of lesions produced. Similar exposure 7 days after inoculation showed 22, 30 and 43 per cent inhibition, respectively. Thiouracil and staling products of *Aspergillus niger* after 21 days' growth at 22-25°C. as also the leaf extracts of chilli, spinach and strawberry inhibited the virus multiplication.

Attempts to transmit the mango malformation disease by grafting and through the agency of *Idioceras* sp. and *Deltocephalus* sp. have so far proved unsuccessful. The viruses causing mosaic in *Datura metel* and *Hesperis matronalis* were studied. The latter virus could not be transmitted to any other plant species except *H. matronalis*. The thermal-inactivation and dilution-end points of the *Datura metel* virus were found to lie between 60-70° C. and 1:100—1:1,000, respectively, while those of the *H. matronalis* virus were between 70-80° C. and 1:100—1:1,000.

An intensive survey of cultivated plants, including all the local crops, fruits, vegetables, ornamental plants and natural flora, was continued in Poona and Delhi areas and Simla Hills for virus diseases. Survey was also conducted in Kulu Valley and Mandi area. A few suspected cases of virus diseases have been collected and are being studied.

C. Section of Systematic Mycology

30. Taxonomy :

Critical studies on the genera *Cercospora*, *Alternaria*, *Colletotrichum*, *Phyllachora*, *Phyllachorella* and *Catacauma* were made. *Alternaria tenuis* was recorded on 20 hosts. 20 species of *Cercospora* were observed for the first time in the country, while two of *Phyllachora*

and one of *Phyllachorella* were determined as new species. *Cercospora viticola*, *C. woodfordiae*, *C. caladii* var. *colocasiae* and *C. crassa* were changed to *Pseudocercospora vitis*, *Cercospora sydowiana*, *C. colocasiae* and *Alternaria crassa*, respectively. Thirty-nine hosts for the genus *Cercospora* and two for *Colletotrichum* were found to be new to science. The genera *Ciliachorella* Syd. and *Plagionema* Subramanian and Ramakrishnan were found to be synonymous.

Taxonomic studies on Miscellaneous Indian Fungi were continued and the following fungi of interest, not having been reported from India, were recorded :

ASCOMYCETES: *Erysiphe polygoni* on *Iberis* sp. and *Brassica napus*; *Leptosphaeria* sp. on *Eriobotrya japonica*; *Mycosphaerella* sp. on *Phaseolus aureus*; *Cucurbitaria berberidis* on *Berberis* sp.; *Hyperus* sp. on *Artemisia scoparia*; *Rhynchospora* sp. on *Urtica dioica*; *Xylaria* sp. on *Citrus* sp.; *Scolecodothis* sp. on *Phoenix* sp.; *Valsa* sp. on *Mimusops elengi*; *Cryptomyces* sp. on *Quercus incana*; *Tribliidiella rufula* on *Bogounvillaea* sp.; *Peltella* sp. on *Rosa* sp.; and *Peziza* sp.

BASIDIOMYCETES: *Puccinia calthae* on *Caltha palustris* var. *normalis*; *P. pacifica* on *Plantago* sp.; *P. rubigo-vera* on *Thalictrum* sp.; *Frommea* sp. on *Potentilla* sp.; *Cyathus* sp. on *Urtica dioica*; and *Clitopilus* sp.

DEUTEROMYCETES: *Phyllosticta* spp. on *Capparis sepiaria* and *Artocarpus heterophyllus*; *Phoma* spp. on *Cassia occidentale* and *Solanum* sp.; *Selenophoma* sp. on *Eugenia operculata*; *Plenodomus* spp. on *Typha elephantum* and bracts of *Cedrus deodara*; *Cytospora* sp. on *Anona squamosa*; *Phomopsis* sp. on *Vernonia* sp.; *Ceuthospora* sp. on *Litchi chinensis*; *Ascochyta* sp. on *Euphorbia* sp.; *Septoria* spp. on *Cestrum aurantiacum* and *Sarcococca pruniformis*; *Hendersonia* sp. on *Rhododendron arboreum*; *Leptothyrium* sp. on *Artocarpus heterophyllus*; *Fusicoccum* sp. on *Dalbergia sissoo*; *Gloeosporium* spp. on *Rosa* sp., *Eugenia operculata* and *Ipomoea pestigridis*; *Amphichaeta* sp. on *Rhododendron arboreum*; *Ramulispora sorghi* on *Sorghum sudanense*; *Cercospora* spp. on *Capparis sepiaria*, *Pogostemon plectranthoides* and *Medicago sativa*; *C. kaki* on *Diospyros virginiana*, *Chaetostroma* sp. on *Dichanthium annulatum*; *Circinotrichum* sp. on *Thevetia nerifolia*; *Stachylidium* sp. on *Saccharum officinarum*; *Hadrotichum* sp. on *Phragmites* sp.; *Gonatorrhodum* sp. on *Clerodendron* sp.; *Isaria palmae* on *Cocos nucifera*; *Coryneum* sp. on *Psidium guajava*.

Of these, 5 genera (*Scolecodothis*, *Gonatorrhodum*, *Clitopilus*, *Hyperus* and *Cryptomyces*) were recorded for the first time in India and a new genus of Sphaeropsidales was also being studied.

31. Indian Type Culture Collection :

The Culture Collection continued to be a member of the International Federation of Culture Collections linked with UNESCO. About 5,000 sub-cultures of fungi and bacteria on different media were made for their maintenance. Twenty-one fungi were added to the Collection during the period under report, thus bringing the total number of cultures in stock to 957. About 140 fungal and bacterial cultures were supplied to various scientific workers and institutes in the country and abroad.

Mineral oil preservation studies of 130 species of fungi showed that most of the fungi belonging to Ascomycetes, Basidiomycetes and Fungi Imperfecti survived for 4-5 years when preserved in Nujol or B.O.C. 120. *Monascus purpureus* has been found to remain viable for 10 years in hermetically sealed tubes.

32. *Herbarium Cryptogamae Indiae Orientalis* :

In all, 2,042 mycological specimens, which included some important foreign exsiccati sets like *Reliquiae Farlowianae*, were added to the Herbarium, raising the total number of accessions to 22,684. More than 100 specimens and several coloured plates were supplied to various scientific workers and teaching institutes in the country and abroad. A number of mycological specimens, collected locally and received from different sources, were identified.

Regarding exsiccati sets, Fascicle II of "Indian Uredinales" and Fascicle I of "Indian Ustilaginales" were issued to 16 important world Herbaria which have evoked a good response for exchange of fungi. Another exsiccati set of "Indian Cercosporae" is under preparation. A list of Phycomycetous specimens (together with details), present in the Herbarium, was prepared for distribution and similar information for the other groups of fungi will be made available for the use of research workers.

PROGRAMME OF WORK FOR THE YEAR 1955-56

I. Plant Pathological Investigations

- (a) Studies on cereal smuts and bunts.
- (b) Determination of physiologic races of *Ustilago tritici*, *Melampsora lini*, *Puccinia graminis tritici*, *Puccinia glumarum*, *Puccinia triticina* and *Colletotrichum falcatum*.
- (c) Studies on rusts of wheat, barley, maize, sunn-hemp, linseed, safflower and wild grasses.
- (d) Green-ear disease of *bajra*.
- (e) "Molya" disease of wheat and barley.
- (f) Fruit and vegetable diseases, e.g., deficiency disease of Guava in Pushkar Valley; *Macrophoma* leaf spot and twig blight of mango; and *Alternaria* leaf spot of Cruciferous plants.
- (g) Assessment of damage due to certain crop diseases. Aerobiological studies.
- (h) Testing varieties of crop plants evolved by the Botany Division for their resistance to diseases with particular reference to wheat and barley rusts and smuts, linseed rust and pigeonpea wilt.
- (i) Efficacy of different seed-dressing fungicides.
- (j) *Diseases of sugarcane*.—Factors affecting variation in *C. falcatum* and recurrence of the red-rot epidemic; role of the perfect stage of *C. falcatum* in the origin of new virulent strains; virulence of mixed inocula of *C. falcatum* isolates; relative resistance to red-rot of plant and ratoon crops. Evolving of cane varieties resistant to red-rot and smut and studies on inheritance of their resistance (in collaboration with the Director, Sugarcane Breeding Institute, Coimbatore).
- (k) Studies on microbial antagonism and antibiotics; Plant tissue culture; Physiology of Fungi.
- (l) *Bacterial diseases of plants*.—"Tundu" disease of wheat; leaf spot of pomegranate; brown rot of potatoes; and red stripe of sugarcane. Survey of bacterial diseases of plants and association of nematodes with them.
- (m) *Radioactive Isotopes*.—Effects of ionising radiations on soil and plant pathogenic microorganisms; study of factors involved in the wilting of pigeonpea plant due to infection by *F. udum*.

II. Plant Virus Investigations

- a) Studies on mosaic viruses of bottlegourd, papaya, banana, sugarcane, groundnut and gooseberry; yellow-vein mosaic of *bhindi*; sterility disease of pigeonpea; Phyllody of sesamum and Brassica sp.; mango malformation; "Foorkey" disease of large cardamom; "Grassy-shoot" disease of sugarcane; Spike disease of sandal; "Small-leaf" disease of cotton; and virus diseases of citrus and chilli.
- (b) Fundamental studies on virus-vector relationship of "Little-leaf" of *brinjal* and sesamum phyllody; purification of plant viruses and study of their properties; inactivation of plant viruses, development of new strains and cross-protection tests.
- (c) Control of "Katte" disease of cardamom and tomato leaf curl; assessment of losses due to Papaya mosaic and "Katte" disease of cardamom.
- (d) Survey of plant virus diseases.

III. Mycological Investigations

- (a) Taxonomic study of new and unidentified collections available in the Herbarium Crypt, Ind. Orient.; preparation of exsiccata sets of Indian Fungi, list of fungi deposited in the Herbarium and card indices of species of fungi represented in India; identification of fungi and disease specimens and taxonomic studies in the genera *Alternaria*, *Cercospora*, *Tretopileus* and *Diplodia*; and maintenance of Host Index of fungi.
- (b) Maintenance of Indian Type Culture Collection of Microorganisms and their history sheets and study of methods of preservation; cultivation of edible mushrooms.

IV. Miscellaneous

Routine and advisory; post-graduate teaching, and training plant protection and short course students; assistance and advice to Indian Council of Agricultural Research, Indian Central Sugarcane Committee, Indian Central Oilseeds Committee, *etc.*, and Intensive Cultivation Scheme, Delhi State. Also coordination of mycological and plant pathological research.

6. REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

(Shri R. V. Ramiah)

GENERAL

(a) The Division of Agricultural Engineering which was started in the Indian Agricultural Research Institute in the latter part of 1945, has the following objectives :—

1. Conducting research on the indigenous agricultural implements in this country for improving their efficiency and to design new implements which will be cheap and useful for the Indian farmers. They should suit the soil and climatic conditions prevalent in various parts of the country.

2. Testing tractors and power implements to determine their performance and finding out their costs of operation.

3. Making necessary modifications to animal drawn implements imported from other countries with a view to adapt them to the conditions prevailing in different parts of India.

4. Advising the public, the State and Central Governments on various technical problems of mechanised cultivation that arise in the course of normal operations.

(b) The following machines were received during the year, for tests and trials :—

1. "Brosson" Rainer from Messrs. T.E. Thompson & Co., Ltd., Calcutta. This is for applying irrigation water to crop land by spraying.

2. Scythes with handles from European countries.

3. Japanese Paddy Seeder and Seed Loader. This is for seeding paddy nursery.

4. Japanese Weed Extinguisher and fertilizer distributor. This is an adjunct in the Japanese method of paddy cultivation.

5. Japanese Rice Thresher for manual operation.

6. Japanese wheat hand thresher.

(c) The Division rendered technical help and advice needed by the other Divisions of the Institute for the selection, purchase, maintenance and repairs of instruments and machines and approval and inspection of engineering stores and spares. Amongst such work the following may be mentioned :—

- (1) Selection of a tractor together with its necessary implements required by the Agronomy Division for the Agricultural Sub-station, Karnal.

- (2) Preparation of specifications for a tractor and its implements required by the Botany Division for the Botanical Sub-station, Pusa.

- (3) Inspection of furniture required by the Central Office, Library and Hostels.

- (4) Technical help for the repair and maintenance of the machinery in the Activated Sludge Plant (I.A.R.I.).

(5) The Division assisted the Division of Agronomy in maintaining their tractors and agricultural field machinery and attended to their repairs. Two Caterpillar tractors in the Agronomy Division were inspected and checked before handing over to the Central Tractor Organisation from where they had been obtained on loan.

(d) There has been an increasing demand for the supply of working drawings and blue prints of agricultural machinery and implements from various State Governments, implement and machinery manufacturers, and private individuals. Drawings were supplied free of cost to the State Governments and at a cost of Rs. 5 per set to the private parties. During the current year, blue prints of the following machines and implements etc. have been supplied :—

Description.	No. of prints supplied
1. Improved Circular Mhote	1
2. Single Row Rice Land Weeder	2
3. Hand driven Rotary Screen	2
4. Hand driven Rice Sheller	2
5. Paddy Thresher	1
6. Bakhar or Blade Harrow	1
7. Seed Box of Groundnut Planter	1

A number of Indian firms have been benefited by this system of supplying the working drawings of proved agricultural machines and implements without which, they could not have manufactured such machines.

SCHEMES

(a) *Scheme for the Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements*

The above scheme financed by the Indian Council of Agricultural Research was started in the Division from 3-10-53. One of the objectives of this scheme was to introduce and popularise improved implements and machines from one part of the country to another where they are not known and to assess their advantages. Under the scheme all the States of the Union were requested to intimate such items which are considered useful and which they may take up for trial and popularisation in their States. From amongst the list of items prepared, the following have been despatched so far :—

Name of implement or machine	No. supplied
1. Pedal operated paddy thresher	9
2. Bullock-drawn seed drill	6
3. Orissa plough for rice land	7
4. Olpad thresher for wheat threshing	9
5. Rice land weeder—double row	9
6. Grain screen for grading harvested grains	6

Despatch of the following items has also been undertaken through a firm in Coimbatore.—

1. Guntaka or blade harrow.
2. Bund former.
3. Green manure trampler.
4. Wetland puddler.

(b) *Scheme for Importing Foreign Agricultural Implements and Machines and Conducting Trials to Determine Their Suitability under Indian Conditions*

The Planning Commission had made recommendations for initiating the above scheme. Accordingly a scheme, for import and trial of agricultural implements from abroad was submitted to the Ministry of Food and Agriculture (Agriculture) for their consideration.

After the visit of the Minister for Agriculture, Dr. P. S. Deshmukh to Japan, a proposal for importing suitable Japanese agricultural implements and machines under the scheme as well as for the use at the I.A.R.I., was submitted to the Ministry. A sum of Rs. 187,000 has been sanctioned for the year 1955-56 for this purpose.

(c) The following two schemes were sanctioned to be conducted in the Division on the basis of the recommendations of the Planning Commission in the First Five Year Plan :—

(i) *Establishment of a Museum of Agricultural Implements.*—In this scheme, the purpose is to collect implements from different parts of the country and make them available in a central place for inspection and selection by the farmers, implement makers and officers of the agricultural departments. The plans for the buildings have been prepared and submitted to the C.P.W.D. A list of necessary equipment also has been prepared, which would be obtained after the buildings are ready. Recruitment of staff will be taken up when the buildings are ready.

(ii) *Establishment of a Tractor Testing Station.*—This scheme has been started from 15-6-55. An expert from the U.K. Mr. S. J. Wright, who visited India under the Colombo Plan has submitted his recommendation for starting the station and securing the necessary equipment. The accommodation for the Testing Station is provided at present in the two sheds of the Central Tractor Organisation.

DEMONSTRATION OF TRACTORS AND IMPLEMENTS

(a) *Puddling Demonstration by a Ferguson Tractor*

A demonstration of puddling the fields for rice cultivation was made by Messrs. Massey-Harris-Ferguson Co., Bangalore at the farms of the I.A.R.I., on 30-9-54 by a Ferguson Tractor equipped with a puddling implement. The implement consisted of a disc harrow supplemented with levelling attachments and is fixed behind the tractor. The harrow had 12 discs of 18" dia. arranged in two parts in a row of 7'-6" in length. The cut of the disc could be set to any predetermined value. The levelling blades are lifted up when the harrow operates and are put into operation when the disc is lifted up. Thus only one of the two implements, i.e., the levelling blades or the disc harrow operates at a time.

The demonstration was conducted in a field with 3"-4" standing water and lasted for about an hour. The harrows were worked to cut and mix the soil first lengthwise and then breadthwise. Afterwards levelling blades were used lengthwise only to level the ground. The land was puddled to 4"-5" in depth. The firm states that the equipment can puddle an acre of land in $2\frac{1}{2}$ —3 hours. During the demonstration, however, they took 45 minutes to puddle 0.25 acres. The puddling was judged to be satisfactory.

(b) Demonstration of a 'Chief' Garden Tractor

A 5 H.P. 'Chief' garden tractor was demonstrated for field trials in the I.A.R.I. farms on 29-4-55 by Messrs. Gunvantray Brothers, 46 Indra Palace, Connaught Place, New Delhi. The tractor was worked in recently harvested land which was irrigated for this purpose. Side by side, a pair of bullocks with a Victory plough was also worked to compare with the performance of the tractor. The demonstration lasted for about 40 minutes during which the tractor ploughed a $9\frac{1}{60}$ acre plot to 4"-4 $\frac{1}{2}$ " depth, consuming 0.24 gallons of fuel (powerine). It corresponds to 4.44 hours per acre and a consumption of 1.6 gallons of fuel per acre. The bullocks took the same time for ploughing the same area of land to 5"-5 $\frac{1}{2}$ " depth. The tractor was subsequently retained in the Division for conducting further trials.

PARTICIPATION IN EXHIBITIONS

Implements and machines were sent from this Division for display at the All India Cattle Show held at Patiala from 13th to 21st March 1955. The visitors were explained and some implements were demonstrated in the nearby fields.

RESEARCH AND TRIALS

(a) Commercial Tests

The Government of India have approved certain regulations for conducting tests on agricultural implements and machines at the I.A.R.I. Under these regulations, commercial tests of (i) a water lift manufactured by Messrs. Lakshmi Engineering Co., Delhi and (ii) a Paddy Weeder manufactured by Messrs. Gunti & Co., Secunderabad were undertaken.

(i) Water Lift

Modifications carried out by the firm on this bullock operated water lift did not prove successful and the lift continued to give an efficiency of 8.9% with an average output of 2,640 gallons/hour from a depth of 12"-8". The draft was measured as 340 lbs. Consequently the firm has taken it back for making further improvement on this lift.

(ii) Paddy Weeder

This paddy weeder is operated by one man, and is similar to the paddy weeders from Japan. It consists of two sets of claw-type rollers mounted on a boat shaped frame. The rollers have 3 rows of 3 fingers integrally mounted on the plate. The weeder was tested in the fields of the I.A.R.I. where paddy had been transplanted in straight line 8" apart, and had

3'-4" standing water. It was found that the weeder was effective to root out weeds to a depth of $2\frac{1}{2}$ " and could weed 1.16 acres in an hour and forty minutes. The weeder could be useful in paddy growing tracts of India provided paddy is grown in lines and the specified distance between rows is maintained.

(b) Experiments on Seed Bed Preparing Implements

Test of 'Care' Junior Plough

At the instance of the Ministry of Food & Agriculture, the 'Care' $4\frac{1}{2}$ " Junior Plough, designed and fabricated by Messrs. Cossul & Co., Kanpur was tested for its performance. Its output was compared with the 'Care' $6\frac{1}{2}$ " Plough, which had been tested earlier. The 'Care' $4\frac{1}{2}$ " plough is identical in shape with the $6\frac{1}{2}$ " 'Care' plough. The junior plough is fitted with a long wooden beam. The bottom is properly aligned with the beam and handle and there is a special bracket which has got holes for adjustment of shallow or deep ploughing. Its mould board is of the general purpose type. It is made of steel and has got a good finish. The land side and share are made of high carbon steel.

The following data was recorded during the tests :—

Plough	Size of furrow	Total draft in lbs.	Speed of bullocks in miles per hour
'Care' $4\frac{1}{2}$ "	4" wide × 5" deep	260	1.08
'Care' $6\frac{1}{2}$ "	6" wide × 5" deep	280	1.04

Performance of the 'Care' $4\frac{1}{2}$ " plough was satisfactory including soil pulverisation. During the above test a hydraulic self-recording dynamometer was used.

(c) Experiments on Rice Processing Machines and Methods

(i) Trials of a hand operated Japanese paddy huller

A manually operated Japanese paddy huller was tested for its performance. The machine requires three men for its operation, two for operating it and the third man for feeding paddy to the hopper.

The machine proved to be heavy for continuous working by two men. While working at full load, men need to be changed every hour.

The machine gives its best performance when worked at 3000 R.P.M., when the output was 13 to 14 maunds of paddy per day of 8 hours and the percentage of unshelled paddy was 14.4. Several trials were conducted and the average figures of performance recorded were as follows :—

Amount of paddy in seers	Time taken		Whole rice		Broken rice		Husk		Un-shelled paddy	
	Mts.	Secs.	Srs.	Per cent.	Srs.	Per cent.	Srs.	Per cent.	Srs.	Per cent.
10	7	21	5 3/16	51.87	7/16	4.38	2 15/16	29.35	1 7/16	14.4

NOTE.—(1) Percentage of broken rice to whole rice is 8.43.

(2) During the trials, the hopper opening was kept at 1/4th of the opening

(ii) *Comparative study of various Threshing methods*

The indigenous methods of threshing paddy crop by beating it against a basket, wooden plank or floor; threshing by the use of the Japanese pedal thresher and threshing by treading by tractor, were compared for their output etc. The tractor equipped with pneumatic tyres, operated at 8 miles per hour on paddy (grain) plants which were tied in bundles and arranged in strips of about 1"-0" thick in circular fashion. Three men were required in the indigenous method as well as in threshing by tractor operation, while the pedal thresher required one man. The following data was recorded :—

Method	No. of men required	Output of paddy/hour		Remarks
		Mds.	Srs.	
1. Indigenous method	3	1	10	
2. Pedal thresher	1	1	0	
3. Treading by tractor	3	49	2	More time was used in arranging the bundles than in the actual operation.

It was observed that the indigenous method was more laborious than the other two methods. It could be replaced by the pedal operated threshers. Threshing by treading of tractor is under observation and further trials will be conducted. The paddy grains were not damaged in this method.

(d) *Experiments on harvesting implements**Scythes*

In order to determine the suitability of the scythes, an implement used in Western countries for harvesting, under Indian conditions, an attempt was made to secure some scythes from six countries, *viz.*, U.K., U.S.A., Sweden, Denmark, Norway and Switzerland. Six scythes were obtained from the U.K. These scythes were put to use for trial purposes in oat fields ready for harvesting and their data compared with the sickle for performance. The following data was recorded :—

Sl. No	Implement	Time taken for cutting		Trial area	Stock cut in Lbs.	Percentage of stock cut
		Mts.	Sec.			
1	Scythe	3	15	10' × 10'	38	89
	Sickle	6	15	Do.	42	100
2	Scythe	3	10	Do.	39	91
	Sickle	7	15	Do.	46	100
3	Scythe	3	0	Do.	37½	87
	Sickle	7	20	Do.	43	100

The following observations were made during the trial :—

(a) Although in considering the time only for harvesting the crop, the scythe takes only half the time taken by the sickle, but it is felt that the use of the scythe is more tiresome. Further, sufficient practice is required for its use.

(b) The contour of the ground plays an important part in the use of scythes which require a sweeping action for harvesting the crop. With a little practice, the position of the 'cut' with the scythe can be adjusted so that minimum amount of stock is left even on uneven ground.

(c) The use of the scythe leaves the harvested crop in the field and requires subsequent labour to pick it up. This is eliminated during the use of the sickle as the crop is left in hand and is placed at different convenient places.

Under these circumstances the use of scythes (for Indian conditions) does not appear to be very favourable. Efforts are being made to get some more scythes from other western countries through the Indian Embassies when further experiments will be conducted.

(e) *Experiments on water lifts etc.*

(i) *Trials of the 'Charsa'*

'Charsa' is the water-lift with a leather bucket and is used in many parts of India, and is operated by a pair of bullocks and two men in Northern India. One man is required to stand near the well to empty the bucket and other drives the bullocks. The size of the leather bucket varies from place to place depending upon the bullocks' capacity and depth of the water level. In case the depth is more than 50 feet, two pairs of bullocks are generally used.

Experiments were conducted last year for determining the efficiency of two types of charsas. An improvement has been effected by providing a self-delivery leather tube to save the labour of one man. The tube is fitted at the bottom of the leather bucket and is held by a rope passing over a pulley and is controlled by the man driving the bullocks. When the charsa is required to be emptied at the ground level, the rope is released, which lowers the tube and the water is discharged. At other times the rope is held to keep the tube vertical, so that it may not discharge. The following observations were made during the comparison of the indigenous type and the improved type of charsa :—

	Indigenous Charsa	Improved Charsa
Capacity of bucket in gallons	29.2	41
Time taken for each lift in seconds	65	36
Discharge gallons/hour	1,620	4,100
Water level after charsa has run for certain time in feet when observations were made	53.5	18
Distance travelled by bullocks, one way in feet	59.5	22
Draft as measured by a spring dynamometer in Lbs.	300	320
Slope percentage, where the bullocks walk	14	14.7
Output Horse Power	0.437	0.373
Input, Horse Power	0.886	0.617
Efficiency percentage	48.2	60.4

The efficiency of the improved charsa, when the water level was 18 feet and the bucket capacity was 41 gallons, was observed as 60.4%.

In order to study the performance of the improved charsa six of them were manufactured and two of them were put for actual use under the Intensive Cultivation work in villages near Delhi.

(ii) *Trials of the circular 'Mhote'*

Experiments were conducted on a Circular Mhote last year for determining its efficiency by placing differential pulleys in the vertical and the horizontal planes. After certain modification it has been possible to get an output of 2,620 gallons of water per hour from a depth of 24 feet and 2,540 gallons per hour from a depth of 28 feet with an average draft of 260 lbs. The efficiency of the system while lifting water from 28 feet was found to be 33.94%. Experiments have confirmed that the installations of differential pulleys in the vertical plane gave higher efficiency (33.94%) than the horizontal plane (29.8%).

(iii) *Trials of two Centrifugal Pumps, 3" × 3" & 4" × 4"*

Two centrifugal pumps manufactured by Messrs. Unique Metal Works, Aligarh, were put to tests for their performance. The pumps were run by the belt-pulley of an Allis-Chalmer Tractor at 1400-1440 R.P.M., when the following data was collected.

	Water level in feet (Suction)	Output in gallons/hour	Water H.P
4" × 4" C.F. Pump.	17	13,200	1.13
	18	11,300	1.27
	19	10,600	1.02
	20	9,900	1.00
	21	7,900	0.81
	22	5,300	.59
3" × 3" C.F. Pump	13	9,900	0.65
	14	9,300	0.645
	15	8,300	0.63
	16	7,500	0.61
	17	7,200	0.62
	19	6,600	0.62
	20	6,100	0.62
	21	5,300	0.562
	22	3,900	0.43

Both the pumps did not suck water beyond a lift of 22 feet. The pumps are essentially low lift pumps and made for agricultural purposes. They are not suitable for other industrial purposes requiring higher head at the discharge side.

(iv) *Trials of bullock driven pump*

A bullock operated pump, manufactured by Messrs. Zamindar Foundry, Batala, was put to tests for its performance and efficiency under the supervision of the experts of the Ford Foundation in Delhi. It is a four cylinder plunger pump, operated by individual crank-shafts by a common horizontal bevel-gear through pinions. A pair of bullocks hitched to a beam of 10'-12' in length rotated with the main common gear at a speed of 2-3 revolutions per minute. Certain improvements were effected in this pump regarding the arrangement of the plungers and cylinders and positions of valves, and an efficiency of 60% was recorded when the output was 1,800 gallons/hour. Certain improvements in the arrangements of the valves are needed and the firm was informed about it.

(f) *Trials of tractors*

(i) *Trials of Russian tractors XT3-7*

Two Russian tractors (XT3-7) operated by petrol have been received in this Division for conducting field tests. These are four wheeled tractors, having twin cylinder engines, with magneto ignition. It has a hydraulic draw bar and is equipped with a single bottom 12" mould board plough. It is said to have a rated H.P. of 10 and a D.B.H.P. of 8. The engine is water cooled, and is hand-cranked for starting. The tractor has 3 lights, two front and one rear, which receive direct current from a generator when the engine is in operation. It has got a belt pulley and power take off also. The tractor has the following special features.

(a) The tractor has got four forward and one special land speed to suit the operation of any special implements. The four forward speeds can be converted to reverse by changing the position of a lever.

(b) The operator's seat and steering can be changed to suit the direction in which tractor may be working.

(c) The tractor can be adjusted to have different ground clearance and track width. This is of advantage in row crop work for inter-cultivation.

The tractor was tested for normal 6" ploughing and gave the following results in 1st gear (land speed equal to 2.5 miles per hour).—

Width of furrow	12 inches
Output in acres/hour	0.274
Petrol consumption in gallons/hour	0.82
Petrol consumption in gallons/acre	2.972
Area ploughed per gallon of fuel consumption	0.445

The tractor was also used as stationary power unit and for road work and its performance was quite satisfactory. It is being retained for further tests.

(ii) *Trials of 'Chief' Tractor*

The 'Chief' garden tractor which was demonstrated by Messrs. Gunvantray Brothers, New Delhi was put to ploughing and discing tests in recently harvested fields of the I.A.R.I. and the following data was recorded:—

	Ploughing		Discing
	I Test	II Test	
Time of operation in minutes	22	51	55
Area ploughed/disc'd, sq. feet	1,960	5,665	14,729
Average depth of ploughing	3½"	3½"	
Fuel consumption in gallons	0.1375	0.3625	0.250
Output in acres/hour	0.123	0.153	0.504
Time required in hours to plough or harrow an acre	8	7	1.9

During the tests it was observed that the clutch arrangement is not proper and requires modifications. Further the petrol feeding system for starting the engine also needs improvements.

The tractor is under further field and garden tests.

(g) *Miscellaneous**Trials of hand push carts and wheels barrows*

At the instance of Dr. P. S. Deshmukh, Union Minister for Agriculture, work was undertaken in this Division to select a cheap and efficient hand push cart and wheel barrow for use by farmers for transporting seed, manure and agricultural produce. It was found that a cheap cart made of mild steel sheets and cast iron wheels was suitable for farm use. It costs Rs. 90 and has a capacity of 13 cubic feet. It was also found that there is very little difference in changing over to rubber tyred wheels and ball bearings when required for farm work. In the wheel barrows one with a single wheel and of 2½ cubic feet capacity with solid rubber wheels costing in all Rs. 65 was found to be satisfactory.

PROGRAMME OF WORK FOR THE YEAR 1955-56

1. Continuation of the I.C.A.R. Scheme for Production, Demonstration, Trial & Popularisation of Improved Agricultural Implements.
2. Opening a Museum of Agricultural Implements at the I.A.R.I.
3. Continuation of the scheme for establishing a Tractor Testing Station.
4. Continued experiments on winnowing fans and grain cleaners.
5. Design and fabrication of bullock drawn implements for placement of fertilizer.
6. Study of sprayers, dusters etc. and construction of bullock drawn sprayers.
7. Experiments on using tractors for rice land cultivation.
8. Experiments on seeding and planting machines.
9. Design and fabrication of bullock drawn reaping machine.
10. Experiments of yokes and harnesses for farm bullocks, specially for the seed bed preparation.
11. Any other project to be suggested by the Ministry of Food and Agriculture.

Part III

APPENDICES

APPENDIX I

GAZETTED STAFF AT THE I. A. R. I., NEW DELHI DURING 1954-55

1. Director Dr. B. P. Pal, M.Sc., Ph.D. (Cantab.), FLS, FBS, FNI.
2. Personal Assistant to Director . . . Shri J. M. Banerjee, M.A.
3. Librarian Shri N. N. Chatterjee, B.Sc., Diploma in Librarianship, Diploma in French, German and Russian.

Division of Agronomy

1. Head of the Division & Principal, Central College of Agriculture. Dr. T. J. Mirchandani, M.Sc., Ph.D. (London), A.I.I.Sc.
2. Agronomist Shri S. Sen, M.Sc.
3. Agronomist Shri A. R. Khan, B.Sc. (Ag.), M.Sc. (Wiscon.) P.G. (Agro.) (Officiating).
4. Agronomist Shri J. J. Chandnani, M.Sc. (Ag.) (Officiated up to 17-2-1955).
Dr. J. N. Sharma, M.Sc. (Ag.) (Offig. from 18-2-1955).
5. Assistant Agronomist Shri J. J. Chandnani, M.Sc. (Ag.) (Reverted with effect from 18-2-1955).
6. Assistant Agronomist F/Lt. R. D. Verma, B.Sc. (Ag.), B.Sc. (Hons.) (Edin.) (On leave out of India).
7. Assistant Agronomist Shri Sher Singh, B.Sc. (Ag.), Assoc. I.A.R.I. (Officiating).
8. Assistant Agronomist Shri K. P. Misra, M.Sc. (Ag.), Assoc. I.A.R.I. (Officiated up to 17-2-1955 *vice* Shri J. J. Chandnani).
9. Assistant Agrostologist Shri P. M. Dabadghao, M.Sc. (On deputation with the Indian Council of Agricultural Research).
10. Assistant Statistician Dr. P. N. Saxena, M.A., Ph.D.
11. Assistant Agronomist (TCA Scheme for agronomic trials with fertilizers). Dr. K. S. Yawalkar, B.Sc., Ph.D., Assoc. I.A.R.I.

Division of Botany

1. Head of the Division Dr. S. M. Sikka, M.Sc., Ph.D.
2. Plant Physiologist Dr. R. D. Asana, M.Sc., Ph.D., D.I.C.
3. Geneticist Dr. A. B. Joshi, M.Sc., Ph.D., Assoc. I.A.R.I.
4. Cytogeneticist Dr. P. N. Bhaduri, M.Sc., Ph.D., F.N.I.

5. Systematic Geneticist Dr. D. Chatterjee, M.Sc., Ph.D. (Lond.).
6. Wheat Breeder (Coordinated Wheat Rust Control Scheme). Dr. G. S. Murti, M.Sc., Ph.D., Assoc. I.A.R.I.
7. Assistant Geneticist Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.
8. Assistant Geneticist Dr. N. L. Dhawan, M.Sc., Ph.D.
9. Assistant Plant Physiologist (Coordinated Scheme for investigation of micro-nutrients). Shri V. S. Mani, M.Sc. (with effect from 14-8-1954).
10. Assistant Plant Physiologist . . . Shri T. J. Malkani, M.Sc.
11. Assistant Wheat Breeder (Coordinated Wheat Rust Control Scheme). Shri S. Sen, M.Sc. (Relieved on 20-6-1955).
12. Assistant Cytogeneticist (Scheme on cytological studies on oilseeds). Shri S. S. Rajan, M.Sc.
13. Assistant Cytogeneticist Dr. M. S. Swaminathan, M.Sc., B.Sc. (Ag.), Ph.D. (Cantab.), Assoc. I.A.R.I.
14. Superintendent of Gardens (Horticulture Section). Shri Ramesh Chandra, B.Sc. (Ag.).
15. Assistant Botanist (Plant Introduction Scheme). Shri S. P. Mittal, M.S., Assoc. I.A.R.I. (with effect from 11-4-1955).

Division of Soil Science and Agricultural Chemistry

1. Head of the Division Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Lond.), D.Sc. (Lond. & Cal.), F.R.I.C.
2. Soil Microbiologist The post is at present lying vacant since 5th April, 1954.
3. Soil Survey Officer Dr. R. V. Tamhane, B.Ag., Ph.D. (Lond.).
4. Biochemist Dr. N. B. Das, M.Sc., Ph.D.
5. Organic Chemist Dr. K. C. Gulati, B.Sc. (Hons. Tech.), M.Sc. (Hons.), Ph.D. (up to 14-7-1954. Since then the post is lying vacant).
6. Fertilizer Technologist Dr. C. N. Acharya, M.Sc., Ph.D., D.Sc. (Lond.), F.R.I.C.
7. Experimental Physicist Dr. C. Dakshinamurti, M.Sc., Ph.D. (Lond.), D.Sc. (Banaras).
8. Soil Scientist (T. C. A. Scheme for determination of soil fertility and fertilizer use). Dr. N. P. Datta, M.Sc., Ph.D.
9. Agronomist (T. C. A. Scheme for determination of soil fertility and fertilizer use). Dr. P. C. Raheja, M.Sc., Ph.D.
10. Cartographer (T. C. A. Scheme for determination of soil fertility and fertilizer use). Shri L. M. Mathur, M.A.B.T., A.S.T. (with effect from 21-9-1954).

11. Statistician (Junior Class II) . . . Shri T. P. Abraham, M.A.
12. Assistant Agricultural Chemist . . . Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I.
13. Assistant Soil Microbiologist . . . Dr. A. Sen, M.Sc., Ph.D., Assoc. I.A.R.I.
14. Assistant Soil Physicist . . . Dr. B. T. Mulwani, B.Ag., M.Sc., Ph.D. (Lond.), D.I.C.
15. Assistant Soil Survey Officer . . . Shri R. S. Murti, M.Sc. (with effect from 13-8-1954).
16. Assistant Soil Survey Officer . . . Dr. K. V. S. Satyanarayana, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I.
17. Assistant Biochemist (Scheme for studies of the chemical composition and nutritive values of wheat). Shri B. M. Lal, M.Sc., Ph.D. (with effect from 1-10-1954).
18. Assistant Organic Chemist . . . Dr. A. R. S. Kartha, M.Sc., Ph.D.
19. Assistant Physical Chemist . . . Shri B. Ramamurthi, M.Sc., A.R.I. (Lond.), Assoc. I.A.R.I.
20. Assistant Soil Chemist . . . Dr. B. V. Subbiah, M.Sc., Ph.D.

Division of Entomology

1. Head of the Division . . . Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C., F.R.E.S., F.E.S.I.
2. Systematic Entomologist . . . Dr. S. Mukherjee, M.Sc., D.Sc., (Expired on 31-10-1954. Since then the post is lying vacant).
3. Insect Ecologist . . . Dr. S. Pradhan, B.Sc. (Hons.), M.Sc., Ph.D. (Lond.), D.Sc., F.R.E.S., F.E.S.I.
4. Assistant Systematic Entomologist . . . Shri C. K. Samuel, B.Sc., Assoc. I.A.R.I. (Retired on 5-4-1955. Since then the post is lying vacant).
5. Assistant Insect Epidemiologist . . . Dr. R. P. Choudhury (On other duty).
Shri H. N. Batra (Officiating from 14-9-1954).
6. Assistant Entomologist . . . Shri S. M. Chatterjee, M.Sc.
7. Assistant Insect Physiologist . . . Dr. Rattan Lal, M.Sc., Ph.D.

Division of Mycology and Plant Pathology

1. Head of the Division . . . { Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I., (On deputation abroad from 2-5-1955).
Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), D.I.C. (officiating with effect from 2-5-1955).
2. Systematic Mycologist . . . { Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), D.I.C.
Dr. S. P. Raychaudhuri, M.Sc., D. Phil (Cal.), F.L.S., Assoc. I. A. R. I. (Officiating Vice Dr. B. L. Chona with effect from 2-5-1955.)
3. Mycologist (Coordinated Wheat Rust Control Scheme). Dr. R. Prasada, M.Sc., D.Sc. (Agra).
4. Assistant Plant Pathologist . . . Dr. M. R. S. Iyenger, M.Sc., Ph.D. (Offg.).
5. Assistant Plant Pathologist . . . Dr. M. L. Gattani, M.Sc., Ph.D. (Minn.).

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| 6. Assistant Virologist . . . | { | Dr. S. P. Raychaudhuri, M.Sc., D.Phil. (Cal.), F.L.S.,
Assoc. I.A.R.I. (On other duty with effect from
2-5-1955). |
| | | Shri D. N. Srivastava, B.Sc. (Ag.), Assoc. I.A.R.I.
(Officiating with effect from 2-5-1955). |
| 7. Assistant Plant Bacteriologist . . . | | Dr. M. K. Hingorani, B.Sc. (Ag.), Ph.D. (Minn.),
Assoc. I.A.R.I. |

Division of Agricultural Engineering

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| 1. Head of the Division . . . | Shri R. V. Ramiah, B.E. (Mech.), M.Sc. (A. E.-
Iowa), M.A.S.A.E. |
| 2. Assistant Engineer . . . | Shri J. S. Manku, B.Sc. (Elec. & Mech. Engg.), A.M.
I.E., A.I.M.E. |
| 3. Assistant Engineer . . . | Shri Ram Partap Singh, B.Sc. (Agric. Engg.), M.Sc.
(Agri.). |

Agricultural Sub-Station, Karnal

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|-------------------------------|-----------------------------------|
| 1. Assistant Agronomist . . . | Shri B. D. Gangulee, B.Sc. (Ag.). |
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Botanical Sub-Station, Pusa

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| 1. Superintendent . . . | Shri M. D. Nandkeolyar, M.Sc. |
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Coordinated Wheat Rust Control Scheme

(a) Simla Centre

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|----------------------------------|---------------------------------------|
| 1. Assistant Wheat Breeder . . . | Dr. S. P. Kohli, M.Sc., Ph.D. |
| 2. Assistant Mycologist . . . | Shri V. C. Lele, M.Sc. (Agric. Bot.). |
| 3. Assistant Mycologist . . . | Shri R. L. Munjal, M.Sc. |

(b) Indore Centre

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| 1. Assistant Wheat Breeder . . . | Shri V. S. Mathur, M.Sc. (Agri.). |
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(c) Wellington Centre

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| 1. Assistant Wheat Breeder . . . | Shri V. K. Srinivasan, M.Sc. |
| 2. Assistant Mycologist . . . | Shri L. M. Joshi, M.Sc. |

(d) Pusa Centre

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| 1. Assistant Wheat Breeder . . . | Shri S. Kedarnath, M.Sc. |
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Co-ordinated Plant Virus Research Scheme

(a) Poona Centre

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| 1. Virus Entomologist . . . | Shri P. M. Verma, M.Sc. |
| 2. Virus Pathologist . . . | Dr. S. P. Kapur, M.Sc., Ph.D. (Lond.). |

(b) Simla Centre

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| 1. Assistant Virus Pathologist . . . | Shri R. N. Azad, B.Sc. (Ag.), Assoc. I.A.R.I. |
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Central College of Agriculture

1. Principal Dr. T. J. Mirchandani, M.Sc., Ph.D. (Lond.) A.I.I.Sc.
2. Lecturer in Agronomy Dr. Jaswant Singh, B.Sc., Ph.D. (Wales). (Up to 27-10-1954 & relieved from duty on 28-10-1954. Since then the post is lying vacant.)
3. Lecturer in Chemistry Dr. W. V. B. Sundara Rao, B.Sc. (Hons.), Ph.D., Assoc. I.A.R.I.
4. Lecturer in Entomology Dr. Sardar Singh, B.Sc., Ph.D. (Cornell.) (Up to 28-2-1955. Since then the post is lying vacant.)
5. Lecturer in Physics Dr. Y. V. Kathavate, M.Sc., Ph.D.
6. Lecturer in Agricultural Engg. Shri J. R. Bodola, B.Sc. (Agril. Engg.).
7. Lecturer in Veterinary Science Dr. Gian Singh, L.V.P. (Hons.), P. G. (Mukteswar).
8. Lecturer in Horticulture Dr. G. S. Randhawa, M.Sc., M.A.S. (Toronto), Ph.D. (Mich.).
9. Lecturer in Mycology Dr. Suryanarayana, M.Sc., Ph.D.
10. Lecturer in English Shri S. L. Vachhar, B.A. (Hons. in Econ.), M.A.
11. Lecturer in Economics Shri A. S. Kalhon, M. A. (with effect from 23-7-1954).

I. A. R. I. Dispensary

1. Civil Assistant Surgeon Dr. R. L. Handa.

APPENDIX II

TRAINING OF STUDENTS AND RESEARCH WORKERS DURING 1954-55

(a) List of Students Awarded the Post-Graduate Diploma

Sl.No.	Name of student	Subject of thesis
<i>Division of Agronomy</i>		
1.	Shri J. P. Patel	Irrigation-cum-manurial experiment on berseem (<i>Trifolium alexandrinum</i>).
2.	,, V. T. Rahate	Effect of different <i>kharif</i> leguminous crops on succeeding wheat crop.
3.	,, Pran Nath	Comparison of response of sulphate of ammonia, farm-yard manure, alone and in combination at different levels on wheat.
4.	,, Pyara Singh Rajput	Studies on the effect of rotations.
5.	,, K. Dutta	Effect of forms and levels of nitrogen in combination with different levels on wheat.
6.	,, D. K. Sharma	Irrigation-cum-manurial trial on wheat.
7.	,, M. B. Lal	Response curve of nitrogen on wheat.
8.	,, A. M. Deshpande	Cultural-cum-manurial experiment on carrot.
9.	,, T. K. Ghosh	Effect of the various nitrogen doses on three varieties of potatoes.
10.	,, W. B. Rahudkar	Relative value of nitrogenous fertilizers and their time of application to the wheat crop.
11.	,, S. P. Roy	Phosphate manuring of Hubam clover and its effect on soil fertility and manurial-cum-cutting trial on <i>Vicia sativa</i> .
12.	,, V. D. Mane	Studies on the optimum time of burying green manure crop for wheat.
<i>Division of Botany</i>		
13.	,, R. K. Agarwal	Studies on the variability of cultivated wheats of India. I. Wheats from Bihar, Bengal, Assam and Orissa.
14.	,, S. Bhaskaran	Studies in autotetraploids of linseed (<i>Linum usitatissimum</i> L.) Pollen tube growth in relation to low seed setting in colchicine induced autotetraploids.
15.	,, J. K. Chandra	Cytogenetical studies on pentaploid hybrids in <i>Triticum</i> .
16.	,, B. V. Das	Study of the inheritance of reaction to stem rust in certain wheat crosses.
17.	,, B. G. Ghawghawe	Inheritance studies in <i>Linum</i> species crosses.

18. Shri S. N. Joshi (A) The classification, evaluation and utilization of breeding and agronomic characters in a collection in field and garden peas.
- (B) Hybrid vigour studies in *Gossypium hirsutum*.
19. „ B. R. Majumdar Cytogenetical studies of some varieties and interspecific hybrids of wheat.

Division of Chemistry.

20. „ V. K. Misra Studies on the effect of mohua cake on the soil micro-flora, soil fertility and crops.
21. „ B. N. Srivastava Study on phytin and other forms of phosphorus in wheat as influenced by manures and fertilizers.
22. „ M. P. Sinha Comparative value of some rapid soil test for nitrogen and phosphorus for crop response on red laterite soils.
23. „ M. N. Malik Studies on the development of saline and alkaline patches on the calcareous soils in the Botanical Sub-station, Pusa.
24. „ N. D. Bhure Studies on the fertilizer value of urea, ammonium nitrate, nitro chalk and sodium nitrate on Delhi soils.
25. „ S. J. Lote Soil survey and profile studies of Potato Breeding Station, Simla.
26. „ K. L. Jadav The chemical composition of the tissues of the wheat plant as a guide to its manurial requirements in Delhi soils.
27. „ M. M. Guha Studies on clay humus complexes in relation to the fertility of some Indian soils.
28. „ M. L. Khybri Study of typical soil profiles of Delhi soil.
29. „ U. P. Misra Biochemical studies on the production of combustible gas from organic materials.
30. „ Baljit Singh Micro-nutrient status of some Delhi soil Profiles.

Division of Entomology

31. „ S. Z. H. Naqvi Some factors influencing the sex ratio in *Bracon (Microbracon) gelechiae* Ashmead (Braconidae: Hymenoptera) an ectophagous larval parasite of the potato tuber moth. *Gnorimoschema operculella* Zeller (Lepidoptera : Gelechiidae:).
32. „ S. K. Bhatia Effect of temperature and humidity on sugarcane stem borer.
33. „ K. R. Thakre Studies on the immature stages of the genera *Bracon*, *Stenobracon* and *Chelonus* (Hymenoptera : Braconidae)
34. „ G. A. Gangrade Bionomics and biology and rate of reproduction of *Apanteles angaleti* Mues. (Hymenoptera : Vipionidae), an endoparasite of the pink bollworm of cotton *Pectinophora* (-*Platyedra*) *gossypiella* Saund (Lepidoptera: Gelichiidae).
35. „ B. K. Rai Comparative efficacy of different insecticidal dusts for the control of locust *Schistocerca gregaria* (Forsk.).

36. Shri R. N. Prasad Comparative toxicity of the films of modern insecticides to the first stage larvae of some internal feeders.
37. „ A. K. Sharma Studies on some Indian Acridids (Orthoptera) with special reference to male genitalia.
38. „ K. Krishnamurthy Studies on the Indian Noctuidae with special reference to male genitalia.
39. „ S. Nagarajan Studies on the effects of low temperature on the biology of *Bracon gelechiae* Ashmd. (Sub-species).
40. „ S. K. Golhani Effect of different temperatures and humidities on *Triphleps senii* Narayanan and Chatterji, a predator of some of the pests of stored cereals in India, and on the insecticidal effect of different chemicals impregnated gunnies on some stored cereal pests.
41. „ H. S. Chachoria Effect of Post-treatment temperature on insect susceptibility to insecticidal films.

Division of Mycology

42. „ V. K. Pathak Correlation of soil and seed fungus flora to pre-emergence seed injury and beneficial effect of fungicidal seed treatment.
43. „ R. K. Grover Comparative morphological, physiological and pathological studies on *Sclerotium rolfsii* and *Ozonium taxanum* var. *parasiticum*.
44. „ H. C. Prasad Studies on Inhibition of radish mosaic virus.
45. „ O. P. Sharma Studies on *Macrophoma* leafspot disease of mango.
46. „ T. V. Subbaiah Studies on the antifungal antibiotic produced by *Bacillus subtilis*.

(b) Students admitted during the year

Agronomy

1. Shri Devendra Nath Puri
2. „ Madan Mohan Gupta
3. „ Nilmani Mitra
4. „ Balwant Govindrao Bathkhal
5. „ Shamsheer Nath Mehta
6. „ Manik Nivrutti Akhade
7. „ Ranbir Singh
8. „ Kashinath Rout
9. „ Jainarayan Bajpai
10. „ Madhukar Bhagwan Patel
11. „ Vithal Narayan Bodade
12. „ Wasudeo Champatrao Bonde
13. „ Rajendra Kumar Tiwari
14. „ Yagya Datta Sharma
15. „ F. M. H. Khalisi
16. „ Nityananda Mohapatra

Botany

17. Shri Blyrarobhotla Radhakrishna Murty
18. „ Trimbak Venimadhav Kaushikkar
19. „ Mysore Nanjundiah Somashekariah
20. „ Debabrata Mukherjee
21. „ Subodh Kumar Jain
22. „ Ram Singh
23. „ Debendranath Ray
24. „ Abala Kanta Sarma
25. „ Rabi Narayan Mohanty
26. „ Shivram Gangaram Ahire
27. „ Dhirendra Singh
28. „ Amrik Singh
29. „ Laxmanbhai Bahocharbhai Lakhani
30. „ C. Kempanna
31. „ Jairaj Solanky
32. Miss Suva Ghose

Chemistry

33. Shri H. M. Basavana
34. „ Namjoshi Narayan Govind
35. „ Makhan Lal Vaishnavi
36. „ Ram Paul Dhir
37. „ Gyanendra Nath Mitra
38. „ Pravinchandra Madhav Lal Mehta
39. „ Moti Lal Kaul
40. „ Ramjee Jogooajee Landey

Entomology

41. „ Bhanu Lakmanrao Bhamburkar
42. „ Saumendra Kumar Das
43. „ Saran Singh Khanaja
44. „ Rattan Lal Sharma
45. „ Shiva Davi Mishra
46. Miss Srinivasan Kanakavalli

Mycology

47. Shri Mohammad Razaq Siddiqui
48. „ Mahendra Deo Mishra
49. „ Yalamanchi Puranchandra Rao
50. „ Rama Nandan Prasad
51. „ Trilochan Singh
52. „ Chiranvuri Sankara Krishna Moorthy
53. „ D. Gundu Rao
54. „ Gajendra Prasad Singh

(c) *Regular short courses**Short Course in Soil Survey*

- | | | |
|----------------------|---|-----------------|
| 1. Shri Jodh Singh | } | 6 months course |
| 2. „ L. H. Herekerur | | |

Short course in Plant protection

- | | | |
|-----------------------|---|-----------------|
| 1. Shri Kulwant Singh | } | 3 months course |
| 2. „ Lashman Rao | | |
| 3. „ K. R. Subbaiah | | |

(d) *Students admitted for other short courses training during the year**Chemistry*

1. Shri J. Raman
2. „ J. M. Seth
3. „ A. R. Sethuraman
4. „ G. L. Pandit

Entomology

1. Shri P. L. Bose
2. „ E. N. Sunder
3. „ A. R. Seethuraman
4. „ J. M. Seth

(e) *Honorary Research Workers admitted during the year**Botany*

1. Shri M. L. Magoon
2. „ K. L. Mehra

Chemistry

1. Shri M. N. Sadaphal
2. „ Manmohan Singh
3. Kumari Shakuntala

Entomology

1. Shri R. N. Katiyar
2. „ Saran Singh
3. „ Joginder Singh
4. „ S. S. Chawla
5. „ S. K. Bhatia
6. Miss V. Bala

APPENDIX III

LIST OF PAPERS PUBLISHED DURING 1954-55

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APPENDIX IV

TALKS BY OLD STUDENTS AND EVENING ADDRESSES DELIVERED DURING THE GOLDEN
JUBILEE CELEBRATIONS

1. *Symposium*: The Symposium was held on the "Agricultural Research in India during the past fifty years" under the Chairmanship of Shri R. S. Krishnaswamy, Vice President, I.C.A.R. The names of persons who read out papers with subjects are given below:—

- (i) Dr. S. M. Sikha, on "50 years' progress in plant breeding"; (ii) Dr. P. Mahashwari on "Vernalisation, Hydroponics and Hormones"; (iii) Dr. K. C. Naik on "50 years' progress in Horticulture (the paper was presented by Dr. A. B. Joshi)"; (iv) Dr. R. S. Vasudeva and Dr. N. Prasad on "50 years' progress in Plant Pathology"; (v) Dr. T. J. Mirchandani and Dr. R. J. Kalamkar on "50 years' progress in Agronomy"; (vi) Dr. R. R. Agarwal and Dr. R. V. Tamhane on "50 years' progress in Soil Science"; (vii) Dr. S. P. Raychaudhary and Dr. H. N. Mukherjee on "50 years' progress in the use of Manures and Fertilizers"; (viii) Dr. J. K. Basu on "Recent progress in Soil Conservation"; (ix) Dr. E. S. Narayanan and Dr. G. A. Patil on "50 years' progress in Agricultural Entomology"; (x) Shri R. V. Ramiah and Shri C. P. Raju on "Recent progress in Farm Implement and Machinery"; (xi) Dr. J. M. Blume on "Radio isotopes in Agricultural Research" and (xii) Dr. K. C. Gulati on "Chemical utilization of Agricultural residues".

2. *Talks by old students of the Institute*: Talks were given by Dr. A. D. Khan (Agronomy) on "The patterns of Soil erosion in U. P." and Dr. T. R. Mehta (Botany) on "The practical approach to Plant-Breeding" under the Chairmanship of Dr. Clifford Taylor. Dr. Pushkarnath presided over two talks given by Dr. S. Krishnaswamy (Entomology) on "Lac cultivation and Entomological aspect of lac research" and Dr. N. Prasad (Mycology) on "Variability and Taxonomy of Fungi". Dr. W. V. B. Sundara Rao (Chemistry) spoke on "Some recent trends in Soil Microbiology" and this was presided by Dr. B. Vishwanath.

3. *Evening addresses*: Evening addresses were delivered on three days by (i) Shri Humayun Kabir, Secretary of the Ministry of Education, on "Our Heritage", (ii) Dr. K. S. Krishnan, Director, National Physical Laboratory, on "Radio-carbon dating" and (iii) Shri U. L. Goswami of the Community Projects Administration on "Community Projects". The president for these lectures were Shri G. V. Mavalankar, Speaker, Lok Sabha, Shri V. T. Krishnamachari, Vice Chairman of the Planning Commission and Shri P. N. Thapar, Secretary of the Ministry of Food & Agriculture respectively.

APPENDIX II

TABLE BY OLD NAMES AND NEW NAMES OF THE COUNTRIES

GENERAL NOTES

The following table gives the names of the countries as they were known in 1871, and as they are known at present. The names in italics are those of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present.

Dr. W. M. S. (1871) was the first to give the names of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present. The names in italics are those of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present.

The names of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present. The names in italics are those of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present.

The names of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present. The names in italics are those of the countries as they were known in 1871, and the names in bold type are those of the countries as they are known at present.

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